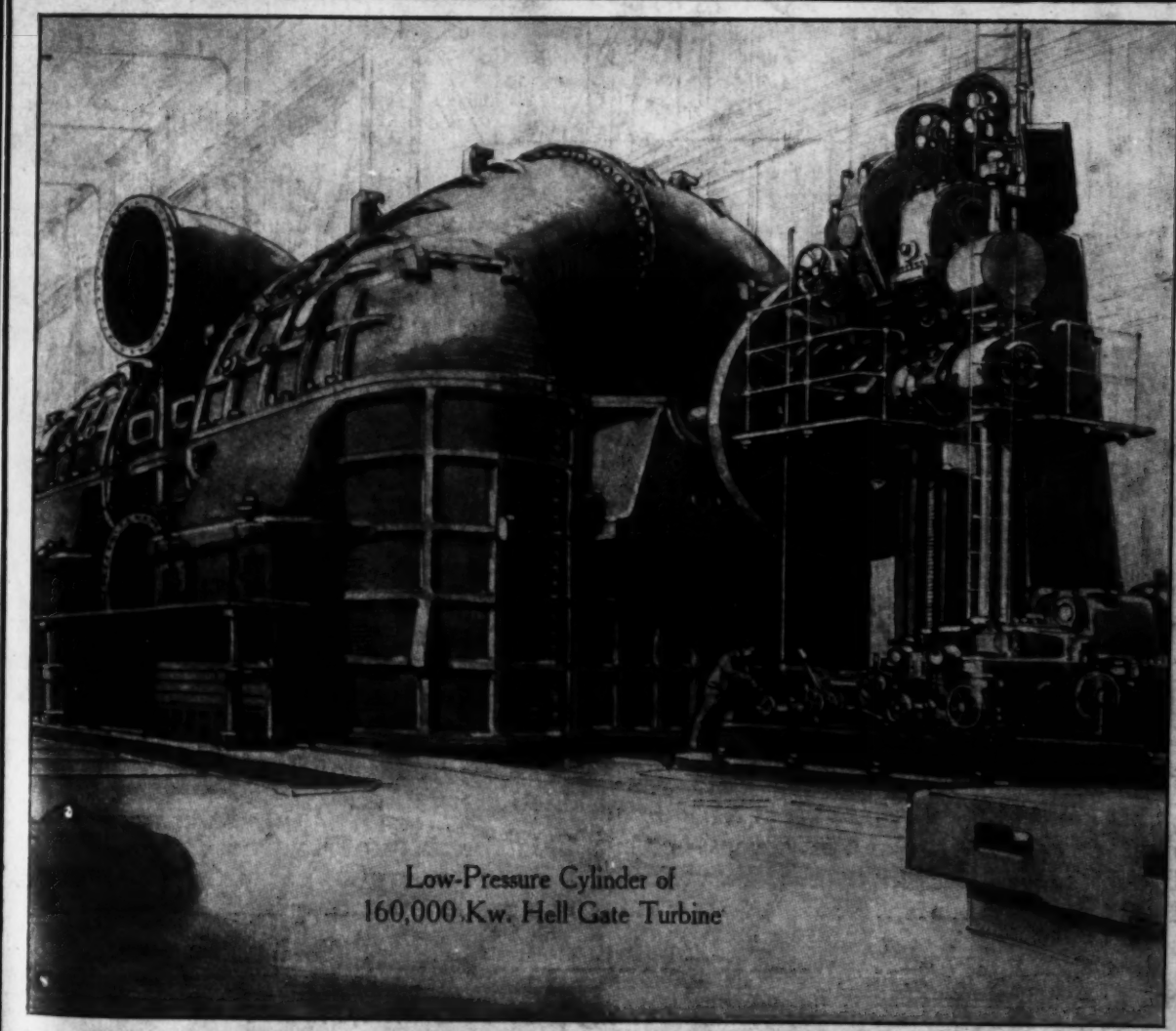
IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

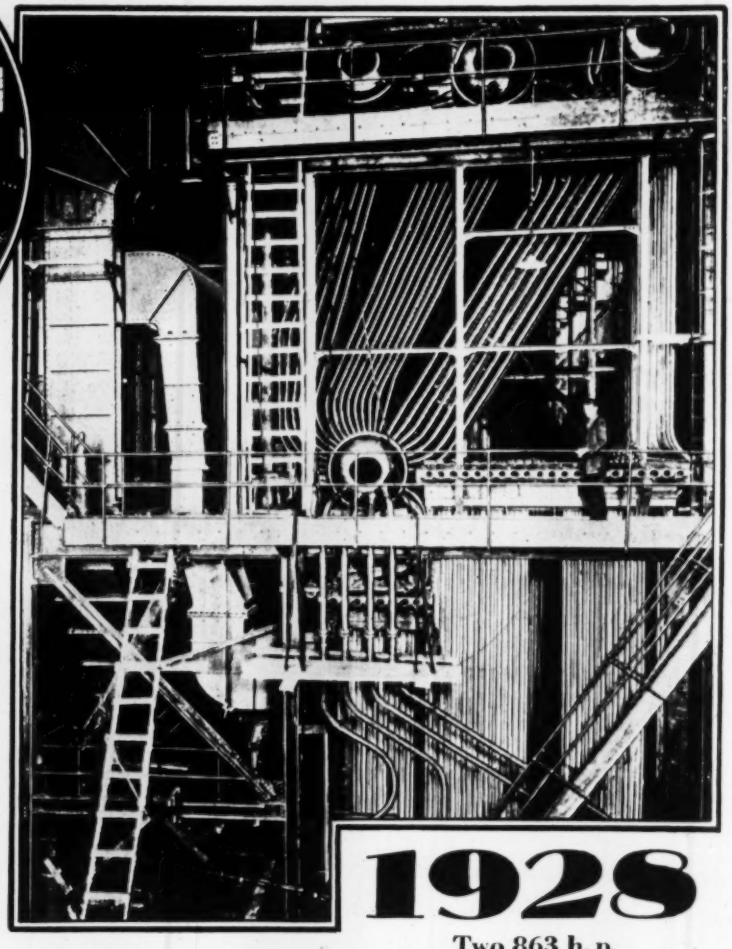


Low-Pressure Cylinder of
160,000 Kw. Hell Gate Turbine

April 1929

1896

Two 269 h. p.
Heine Boilers



Modern Equipment Pays Big— Dividends

1928

Two 863 h. p.
VX Heine Boilers

In 1896 the Proximity Manufacturing Company, Greensboro, N. C., first installed Heine Boilers. Nine repeat orders have been received.

In 1928 two steam generating units comprising two 863 h. p. Heine VX Boilers equipped with C-E Fin Furnaces, C-E Air Preheaters and fired by Lopulco Pulverized Fuel Systems were installed.

90,000 lb. of steam per hour is secured from each of these units, or more than the combined output of 16 of the former units.

This is a striking example of the advantages to be secured through modern steam production methods.

This company offers One Contract—One Responsibility—for complete fuel burning and steam generating installations.

COMBUSTION ENGINEERING CORPORATION

International Combustion Building 200 Madison Ave., New York

A Subsidiary of

INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

COMBUSTION ENGINEERING

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. - Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York

Volume 51 | April, 1929, Section One | Number 4

CONTENTS OF THIS ISSUE

Operation of High-Pressure Steam-Electric Generating Stations — *I. E. Moultrop* — 259
High-Pressure Steam Plants—The American Viewpoint — *A. R. Smith* — 265
The Use of High-Pressure Steam in Europe in Economic Power Generation — *S. Löffler* — 266
High-Pressure Steam-Electric Plant of the Witkowitz Collieries, Czechoslovakia — *J. Havlicek* — 267
Research in Germany — *J. M. Spitzglass* — 275
The Mechanical Properties of Materials as Shown by Studies on Single Crystals — *W. P. Davey* — 280
Halving the Working Force and Stopping Production Leaks Through Simplified Production Control — *K. R. Wood* — 283
Apprentice System of Lynn Plant, General Electric Company — *C. K. Tripp* — 285
Does Mass Production Lessen the Need for Trade Skill? — *H. A. Frommelt* — 287
Experience in the Selection of Apprentices With the Aid of Tests — *W. S. Berry* — 288
Elastic Failure and Fatigue Failure of Metals — *H. F. Moore* — 290
Research and Standardization of Cast-Iron Pipe Now in Progress — 294
Engineering Principles in the Machinery of the Stars — *A. S. Eddington* — 295
Instruments and Apparatus—Preliminary Draft of Part 13—Speed Measurement — 311
Revisions and Addenda to the Boiler Construction Code — 315
Synopses of A.S.M.E. Transactions Papers — 327

DEPARTMENTAL

Survey of Engineering Progress — 299
A Review of Attainment in Mechanical Engineering and Related Fields
Engineering and Industrial Standardization — 313
Industrial Standardization Pays; Refrigerators; Plumbing Equipment; New Standards Yearbook for 1929; The Pedestrian's Rights
Work of A.S.M.E. Boiler Code Committee — 318
Correspondence — 319
Wages of Engineers
The Conference Table — 320
Discussion of Questions on Fuels, Power, Wood Industries, etc.
Editorials — 322
"What It's All About;" Summer School for Mechanical Engineering Teachers; Mechanical Springs; "Energy From the Atom;" Auto Speed Trials at Daytona
Book Reviews and Library Notes — 324
The Engineering Index — 329

ADVERTISING

Display Advertisements — 1
Classified List of Mechanical Equipment — 34
Professional Engineering Service Section — 134
Opportunity Advertisements — 138
Alphabetical List of Advertisers — 140

Section Two—News of Mechanical Engineering

Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada, 75 Cents Additional; to Foreign Countries, $1.50 Additional. Changes of Address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on January 17, 1921.

Copyrighted, 1929, by The American Society of Mechanical Engineers

W. S. Berry

K. R. Wood

I. E. Moultrop

C. K. Tripp

H. F. Moore

Contributors to This Issue

I. E. Moultrop, chief engineer since 1925 of the Edison Electric Illuminating Co. of Boston, has been associated with that concern since 1892. Previous to that time he was connected with the Whittier Machine Co., Roxbury, Mass., for ten years. Mr. Moultrop has served as manager and as vice-president of The American Society of Mechanical Engineers, on the board of managers of the American Institute of Electrical Engineers, and as chairman for three years of the technical section of the National Electric Light Association, and has recently been elected vice-president of the American Engineering Council. He is also a founder of the Engineers' Club of Boston and now its president.

Jaroslav Havlicek, who writes in this issue on "The High-Pressure Steam-Electric Plant of the Witkowitz Collieries, Czechoslovakia" is the engineer of that plant. He was formerly professor in ordinary at the Royal University at Zagreb.

Henry F. Moore, professor of engineering materials at the Engineering Experiment Station of the University of Illinois, received his B.S. and D.Sc. from the New Hampshire College of Agriculture and Mechanic Arts, and his M.E. and M.M.E. from Cornell University. From 1900 to 1903 he served as instructor at Cornell, and was then for a year connected with the Riehlé Brothers Testing Machine Co. in Philadelphia. Later he was for three years on the faculty of the University of Wisconsin as instructor and assistant professor of applied mechanics, resigning in 1907 to become connected with the University of Illinois.

Jacob M. Spitzglass, vice-president and consulting engineer of the Republic Flow Meters Co., Chicago, Ill., was born in Russia. After unsuccessful attempts to obtain a technical education there he came to this country, and in 1909 was graduated from the Armour Institute of Technology with the degree of B.S. in mechanical engineering. Four years later he received his M.E. His first position after graduation was with the Northwestern Gas Light & Coke Co. Then for a year he was connected with the Armour Glue Works. He later was engaged to do experimental work for the People's Gas Light & Coke Co. and won recognition for his work relating to the flow of fluids through pipes. He improved and developed the Gebhardt steam meter. This meter is now being manufactured by the Republic Flow Meters Co.

Wheeler P. Davey, professor of physical chemistry at Pennsylvania State College, received his A.B. degree from Western Reserve University in 1906, his M.S. degree from Pennsylvania State College in 1911 and his Ph.D. from Cornell University in 1914. For three years he served as an instructor of physics at Cornell, and in 1913 was research fellow under a grant from the Huntington Fund for Cancer Research, later becoming physicist at the research laboratory of the General Electric Co. in Schenectady.

C. K. Tripp, superintendent of apprentices, General Electric Co., Lynn, Mass., since 1902, was educated in the schools of Schenectady, N. Y. He served a four-year machinist apprenticeship course with the Schenectady Locomotive Works, and was then connected for short periods with the Edison Co. in Schenectady, and the Thomson-Houston Co. and American Ordnance Co. in Lynn.

K. R. Wood, production manager of the Bell & Howell Co., Chicago, received his early mechanical training in the machine shops of the F. A. Whitney Carriage Co., Leominster, Mass., later being connected with a number of New England mechanical establishments. Following his connection as shop foreman and chief inspector with the Liberty Tool & Gauge Works and as sales engineer with the Taft-Pierce Manufacturing Co., of Woonsocket, R. I., he entered the employ of his present concern, the Bell & Howard Co.

Walter S. Berry, for the past ten years director of training at the Scovill Manufacturing Co., Waterbury, Conn., served an apprenticeship in the machinist trade and then entered the mechanical engineering course of Michigan University. Because of ill health he did not complete his course, but later he was graduated from the College of Teachers of the University of Cincinnati, and then taught for five years in the Industrial Department of the Cincinnati public schools.

H. A. Frommelt, consultant in industrial education, St. Louis, Mo., has received the degrees of B.S., E.E. and A.S. from the University of St. Louis. From 1913 to 1917 he was engaged in consulting engineering work in the design and installation of power transmission in and about St. Louis. For two years he served on the faculty of Marquette University as professor of engineering, resigning to become apprentice superintendent of the Falk Co. in Milwaukee, Wis.

This Month's Cover shows a view of the low-pressure side of the Brown-Boveri 160,000-kw. steam turbine installed in the Hell Gate plant of the United Electric Light & Power Company, New York City, which is now the largest unit in operation anywhere. It is a cross-compound machine, the high-pressure part running at 1800 r.p.m. and the low-pressure at 1200 r.p.m. Steam at 265 lb. pressure and 200 deg. fahr. superheat is applied to the high-pressure cylinder, and enters the low-pressure cylinder at approximately 23 lb. pressure at full load. Arrangements are made for two-stage bleeding. At maximum load, 1,710,000 lb. of steam will be admitted to the turbine per hour when running non-bleeding, which corresponds to about 3600 gal. of feedwater per minute.

MECHANICAL ENGINEERING

Volume 51 April, 1929 No. 4

Operation of High-Pressure Steam-Electric Generating Stations

An Account of the Experience Gained in Operating the Edgar Station of the Edison Electric Illuminating Co., of Boston, Mass., From Which It Is Concluded That High-Pressure (1200-Lb.) Steam Is Entirely Practicable for Electric Power Generation

By I. E. MOULTROP,[1] BOSTON, MASS.

IN A PREVIOUS paper[2] the various factors entering into the design and construction of high-pressure steam stations were discussed with particular emphasis upon the Edgar Station of The Edison Electric Illuminating Company of Boston. It is the purpose of the present paper to give an account of our experience in operating this station and, so far as possible, to stress that part which relates to high-pressure equipment.

The Original 1200-Lb. Installation

A few years ago when steam pressures were advancing moderately a new station did not have to be committed to the designed pressure if this later appeared undesirable. It was at that time always possible to drop back to the original pressure, without any material loss of capacity and consequent increased station cost per unit of capacity. When studies indicated that 1200 lb. was the economic pressure for the Edgar Station, it became evident that there could be no retreat with the entire equipment to the normal pressure of the period. For this reason it was decided to superimpose a 1200-lb. pressure plant upon a portion of a plant constructed for a normal pressure of 350 lb. and to use the exhaust of the high-pressure plant after being reheated to partially feed the 350-lb. turbines. This placed the uncertainties of the development upon a minor part of the equipment, a single high-pressure boiler and a small high-pressure turbine. This equipment has been many times described in the technical press and elsewhere.[3]

The normal 350-lb.-pressure plant operates at a pressure 50 lb. higher than, and at a temperature 80 deg. fahr. in excess of, the maximum pressure and temperature we had previously used. Aside from these slight increases, this part of the station differs from our previous plants only in the change from single- to two-stage bleeding, the employment of complete a-c. auxiliary drive, and the use of evaporators and deaerators in our boiler-feed system. These relatively simple changes in equipment have caused no anxiety regarding the ease and safety in operating the plant, and have proved to be of decided advantage.

Fig. 1 shows diagrammatically the plan of connecting the original high-pressure equipment to this normal-pressure plant. As will be noted, a bypass was put around the original high-pressure turbine primarily to keep the high-pressure safety valves from blowing in case the high-pressure turbine tripped out, and to contribute to the supply of steam to the 350-lb. main in case the high-pressure unit was out of service.

In order that these functions should be carried out under emergency conditions, this bypass valve was made automatic and so connected that it would open with the tripping of the throttle on the high-pressure unit.

It should be observed that, although we were starting out so as to be able to retrace our steps, nevertheless we found it desirable to plan so that if high pressure proved to be practical we could proceed without further consideration of a normal-pressure plant.

For this reason it seemed desirable to install motor drive for all auxiliary equipment in the plant in order to keep the steam piping at a minimum and as simple as possible. This plan was adopted, but since it was possible to use 350 lb. steam pressure because of the features of design previously described, we installed for operation at this pressure one emergency normal-pressure boiler-feed pump, one emergency high-pressure boiler-feed pump, one emergency house generator, one emergency exciter, starting oil pumps of all turbines, and soot blowers.

Precautionary Measures

With this pioneer installation of high pressure it also appeared desirable to take several precautionary measures in order to avoid anticipated difficulties with the consequent outage of equipment and reduction of station capacity. For example, we were not certain that a 1200-lb. safety valve could blow more than once without requiring reseating. Two pilot valves were therefore installed to warn the operators to take steps to keep the main valve from blowing. These pilot valves were each in series with globe valves so that they might easily be disconnected for repair after taking the wear and saving the main valve. These small pilot safety valves, however, were found entirely unnecessary and have been removed.

Another precautionary measure was the installation of a desuperheater in connection with the automatic throttle trip of the high-pressure turbine. This was installed because it was our belief that the steam when throttled through the bypass valve would reach an excessive temperature when leaving the reheater unless desuperheated. We also found that this too was unnecessary because of the combined characteristics of the

[1] Chief Engineer, Edison Electric Illuminating Company. Mem. A.S.M.E.

[2] "High-Pressure Steam-Electric Generating Stations—Design and Construction," by I. E. Moultrop. Presented at a meeting of the Metropolitan Section of the A.S.M.E., New York, February 4, 1929.

[3] See Trans. A.S.M.E., vol. 50, no. 15, May-August, 1928, p 32.

Presented at a meeting of the Metropolitan Section of the A.S.M.E., New York, February 4, 1929.

boiler and reheater. Also, since we did not know the exact temperatures which might be reached at the reheater outlet under all conditions of load for this combination, we installed a bypass damper, by means of which the outlet steam temperature could be regulated. The design of this damper has been fully described in previous articles. In operation we have never had occasion to use it except as a baffle. It is kept in the maximum-temperature position at all times.

We had looked forward to having some trouble in synchronizing the high-pressure turbine, therefore a laminated field with a

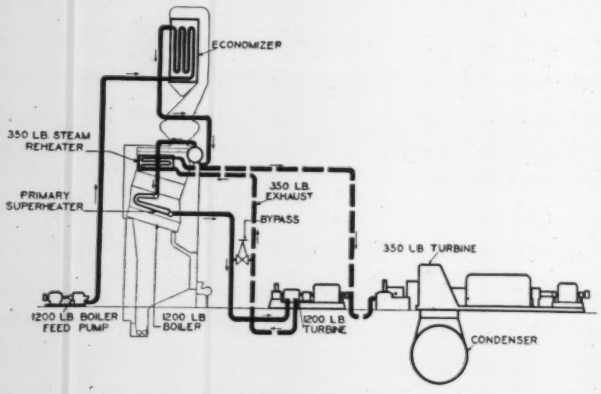


FIG. 1 DIAGRAM SHOWING STEAM AND WATER FLOW IN THE ORIGINAL 1200-LB. INSTALLATION

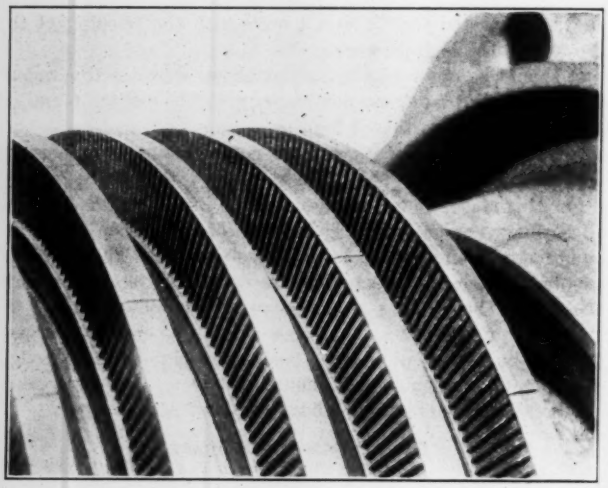


FIG. 2 APPEARANCE OF ORIGINAL HIGH-PRESSURE TURBINE ROTOR AFTER 1600 HOURS OF SERVICE

squirrel-cage winding was provided in the generator as first installed, so that the machine could be connected to the system even though not exactly in synchronism. In practice we found that there was no difficulty in synchronizing the machine, but since this special field caused undue vibration, the manufacturer changed it to the solid type and thus eliminated this trouble.

EXPERIENCES WITH THE 1200-LB. BOILER

Although many of the boiler troubles which we looked for and for which we were prepared did not occur, we have nevertheless had real experiences which were not anticipated.

At the time the first high-pressure boiler was installed, no feedwater regulators had been developed for the pressure used. Although we knew nothing of the water-level stability in a high-pressure boiler, we did not anticipate any trouble in maintaining a constant level in the boiler drum. We had poor regulation, it is true, but this was not a function of boiler design, but of the differential pressure across the feed valves, which was several times greater than ever before encountered. Since these valves were hand operated we had both high and low water. The high water caused no damage, although several times it was carried over into the turbine. The low water, however, may have contributed to the trouble which we have experienced with warped tubes. It cannot be definitely stated that the warping of the lower row of tubes was due to low water, but this may reasonably be assumed. Finally, our difficulties in feeding the boiler came to an end with the installation of feedwater regulators. These in general have proved satisfactory, but they required several modifications to adapt them to high-pressure service.

We have experienced considerable trouble with economizer tube leakage due to insufficient rolling when installed. Inasmuch as this trouble occurred on low-pressure economizers as well as the first high-pressure economizer, it cannot be attributed to high pressure.

When the plant was started we had indications of corrosion in our economizers. This corrosion was caused, we believe, by dissolved oxygen in the feed system. Fortunately the economizers took the brunt of this attack, and in functioning as chemical deaerators apparently saved the boilers from any corrosion. At the time this corrosion was discovered, to be on the safe side we began to treat our boilers internally while we

FIG. 3 APPEARANCE OF LAST STAGES OF THE ORIGINAL HIGH-PRESSURE TURBINE ROTOR WHEN INSPECTED IN JANUARY, 1929

were correcting the difficulty with our deaerating equipment. We now run zero oxygen in our boiler-feed system, and have practically arrested the corrosion. We hope that we shall be able to eliminate corrosion entirely by feeding chemicals through

the feed system so as to maintain a slightly alkaline feed rather than a neutral or slightly acid feed as at present.

The drop in pressure between boiler and turbine is greater than expected, and we find that we are not able to get the expected amount of steam through the turbine at this decreased throttle pressure. For this reason we run the high-pressure boiler somewhat under the capacity of its stoker, except when we are short of 350-lb. steam. In this case we crack the bypass valve around the turbine. This operation, however, results in an increased line drop, with consequent slight reduction of throttle pressure and of high-pressure-unit load. We have found that it is impossible to keep the high-pressure boiler on the line over one week when running with the turbine bypass open on account of slag accumulation on the lower tubes of the boiler. This slag is caused by the high furnace rating. Recently slagging soot blowers have been installed and we hope that this trouble will be eliminated. Up to the time of writing we have not had an opportunity to give this arrangement a thorough test.

Experiences With the Original 1200-Lb. Turbine

The first trouble experienced with the original high-pressure turbine was with the shaft packing. Carbon packing rings were placed in series with two sets of labyrinth packing on the high-pressure end and a single set of the same packing on the low-pressure end. The carbon packing seized and went to pieces. It was replaced with the labyrinth type, which has since proved very satisfactory.

An inspection of the high-pressure unit after 1600 hours of service revealed bent buckets in the first two and last two rows, as shown in Fig. 2. We were unable to account for this, and concluded that it must have been caused by some foreign material. The unit was first put in service December 5, 1925, and up to December 31, 1928, had 16,042 hours of service out of a possible 26,928 to its credit, and had generated 31,829,000 kw-hr. It has been practically a 100 per cent reliable unit, its outage being caused mainly by the necessity for boiler cleaning, as well as for stoker and furnace repairs.

Early in January, 1929, this machine was opened for inspection. The buckets were corroded and there were considerable deposits in the nozzles as well as on the buckets. Five first-stage buckets were found cracked at the root and were removed, as were an equal number on the opposite side of the wheel to maintain balance. The unit has been closed up and put back in service pending a decision on what is to be done with the rotor. Fig. 3 shows the last stages of the rotor at the time of this inspection.

The loading of this unit is necessarily a function of the boiler output. Our original intention was to run the boiler at variable pressures according to boiler output, allowing the turbine to drift. But the governor was found to control the unit satisfactorily and it was decided to run the boiler at constant pressure. Our practice is to use high pressure to the fullest extent possible, and we have never had to operate with varying pressure. Had we attempted to operate this boiler and turbine at varying pressure, we should have discovered that such a procedure was impracticable for several reasons which will be brought out in connection with later superheater failures.

It is to be observed that the loading of the high-pressure turbine and boiler offered no difficulty. We put the equipment in service and allowed it to run at a fixed load, the system base load always creating a demand for the exhaust steam.

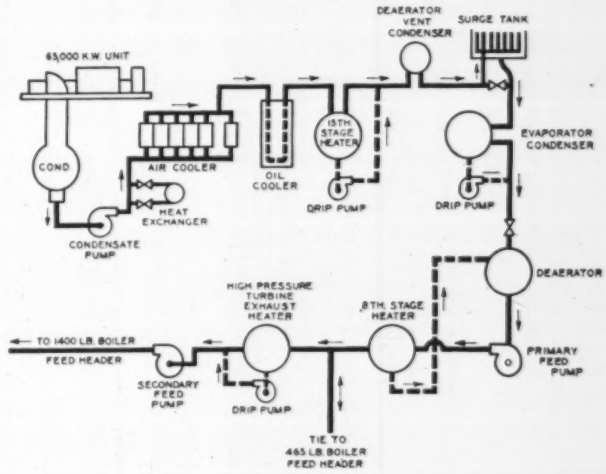


FIG. 4 CONDENSATE AND BOILER-FEED SYSTEM, EDGAR STATION EXTENSION

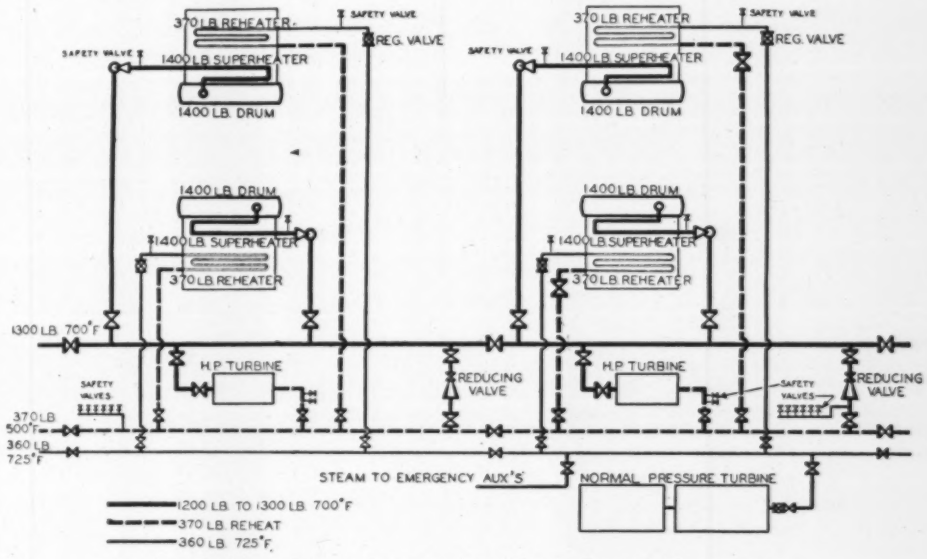


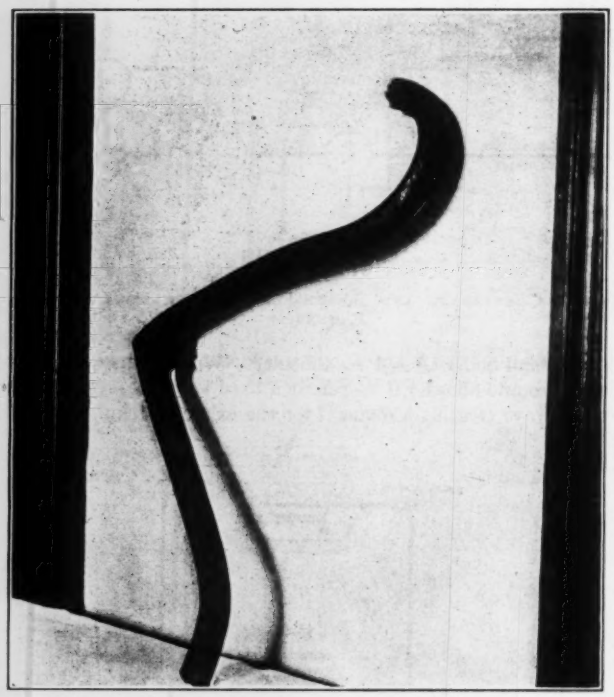
FIG. 5 STEAM-PIPING ARRANGEMENT, EDGAR STATION EXTENSION

Experiences With the Original 1200-Lb. Boiler-Feed Pumps

The feed-pumping equipment in the original 1200-lb. installation consists of two 300-g.p.m. pumps, one running at 3500 r.p.m. and the other at 4500 r.p.m. The 3500-r.p.m. pump is motor-driven and the other pump steam-driven. The steam-driven pump has given no trouble and has had very little service. The motor pump has been run approximately the same number of hours as the original high-pressure boiler. The principal difficulty with this pump has been the wearing of its hydraulic thrust plate, which has to be replaced about once in two months. We had some difficulty in packing this pump at first, but it is now satisfactory in this respect. There was also leakage between the pump shaft and the packing sleeve.

RECENT ADDITION TO CAPACITY AT 1200 LB. PRESSURE

When the time came to put in additional capacity at the station, the question arose of continuing with 1200 lb. pressure at the boilers with reduced pressure at the high-pressure-turbine throttles, or to increase the future boiler pressure so as to give 1200 lb. at the throttles as originally intended. In one case we were faced with an obvious loss in economy due to a pressure which was not up to our expectation; in the other, with difficulties in the way of operating boilers in parallel and the emergency use of pumps. The final decision in the matter was to take the step at this time to 1400 lb. boiler pressure for the new boilers, giving 1200 lb. at the throttle. While this adds complexity to the station as it stands today, the ultimate result will be more satisfactory from all points of view.



FIGS. 6 AND 7 SUPERHEATER TUBES RUPTURED BECAUSE OF FAULTY STEAM DISTRIBUTION IN THE SUPERHEATER. 1400-LB. BOILERS

The pressure having been settled, we proceeded to install two 1400-lb. boilers and one 10,000-kw. high-pressure unit as described in the previous paper.[2]

OPERATING FLEXIBILITY

Figs. 4 and 5 are respectively water- and steam-flow diagrams for the recent 1200-lb. addition to the station. It is evident from a study of these diagrams that, irrespective of the fact that we have three different boiler pressures, we have a high degree of flexibility in the operation of the plant. Steam from any boiler can be used in any low-pressure turbine, but the distribution of boiler-room load between high- and low-pressure boilers is at present under hand control and is now accomplished by the regulation of load on the high-pressure turbines, the low-pressure boilers taking the variations on the automatic boiler control.

In order to make the plant flexible so that any boiler can supply steam to any low-pressure turbine, it becomes necessary to have a common tie at some point in the condensate return. This is accomplished by means of a 500-lb. tie line between the feed pumps for the high-pressure and low-pressure plants. The reason the tie has been continued at this point is because the surge tanks are at different levels. Having no other common point at which to tie them has also forced us to continue to split our pumping pressures at 500 lb. The transfer of condensate is accomplished by varying the speed of the 500-lb. pumps as indicated by the surge-tank levels. Between the two surge tanks also are other transfer arrangements which function automatically at high or low levels. In practice we have had no difficulty in maintaining either proper steam or water distribution in the plant.

EXPERIENCES WITH 1400-LB. BOILERS

The first high-pressure boiler in our recent addition went into service in September, 1927. Since that time we have had a varied series of experiences, not all due to high pressure, but largely to other features of new development.

During the early stages of operation we ruptured several superheater tubes on both of the new high-pressure boilers. Figs. 6 and 7 illustrate two of these failures, which were caused by faulty steam distribution in the superheater. Further failures have been prevented by changing the distribution baffles in the superheater headers, and by installing ferrules in the first pass of the superheater. Apparently this source of trouble is now behind us.

During the time when ruptures were occurring in the superheater, it developed that there was a hazard in running the boiler pressures considerably below the popping pressure of the superheater safety valves. Under these conditions, in case of sudden loss of load on the station, the superheater valve would not blow and thus allow steam to cool the superheater until sufficient steam had been generated to raise the pressure in the boiler to the popping point of the safety valves. The interval of time required for this was sufficient for the superheaters to become overheated. It also developed that in calculations for high-pressure boilers, allowance should be made for the higher volume of low-pressure steam so as to permit operation at low pressure.

About the time when the superheater tubes were bursting, a rear water-wall tube ruptured just above the ashpit. This failure, shown in Fig. 8, was attributed by the manufacturers to faulty circulation due to inadequate capacity in water feeders, recirculators, and steam vents from the upper wall header to the boiler drum. The number of feeders and of recirculation and steam vent pipes was increased, and we looked for the end of this trouble. Recently, however, after the changes had been made, a similar rupture occurred in the rear wall of the other boiler. Fig. 9 illustrates this failure and shows the larger opening which occurs when the tubes are covered with cast-iron waffle blocks, as compared with Fig. 8, where the tubes were covered with steel blocks.

The theory has been advanced that possibly this last water-

wall failure may be attributed to blow-torch action on the wall. In order to prevent a recurrence of this trouble, refractory-faced blocks were installed in place of the cast-iron waffle blocks near the clinker pit on the rear wall. While this measure may be effective, it is our opinion also that variations in water level in the boiler drum change the hydraulic head sufficiently on the wall feeders to unbalance the circulation and cause trouble. This opinion was strengthened when later a feedwater regulator stuck, allowing the water level to drop to approximately two inches above the bottom of the gage glass, when leaking was noted in a wall feeder at the point where it is rolled into the drum. In opposition to this theory, however, it has been suggested that the leakage was caused by a sudden increase of boiler feed at this time. Whatever might have been the cause, it is evident that the condition must be remedied.

Bringing a cold boiler into service has been a frequent cause for leaks of this nature in water-wall supply tubes where they are rolled into the drum. The theory advanced is that when starting up and bringing the boiler up to pressure, the boiler tubes absorb heat more rapidly than the water walls. This hot water is not drawn from the drum into the water walls, as circulation in the latter has not yet started. Consequently there is a difference of temperature of approximately 200 deg. fahr. between the water-wall feeders and the boiler drum, causing expansion and leakage at the point of rolling the tube into the boiler drum. This theory is borne out by the fact that artificial circulation set up by bleeding a small quantity of water from

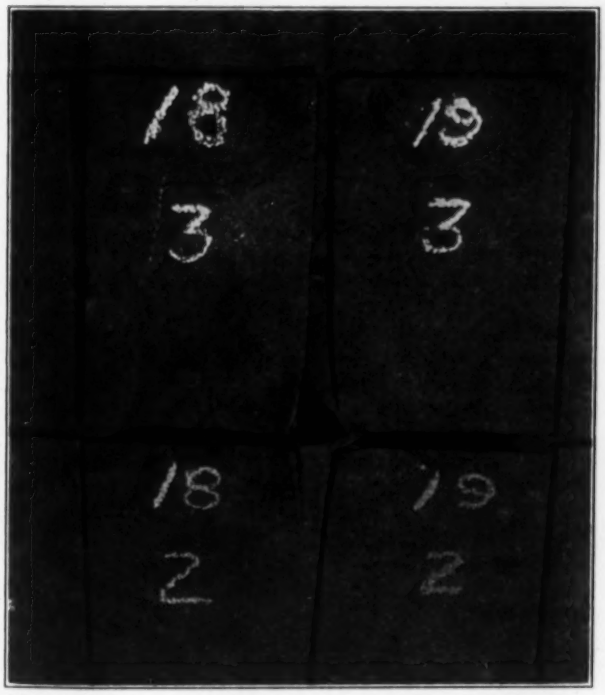


FIG. 8 RUPTURE OF REAR WATER-WALL TUBE JUST ABOVE THE ASHPIT. TUBES COVERED WITH STEEL BLOCKS. 1400-LB. BOILERS

the bottom of the wall, while starting up, has caused this trouble to disappear.

Recently it was discovered that several of the 2-in. boiler tubes in the upper bank of the last two boilers had been overheated. On one of the boilers, one tube was bagged and leaked, and several others showed signs of distress. Investigation disclosed an exceptional concentration of flame close to the uptake headers and extending to the top of the first pass, largely due to the heavy accumulation of slag in the bottom of the boiler. This produced an unusual localization of heat on the bottom tubes of the upper deck. The condition was investigated by the manufacturer and corrected by diverting water from the lower to the upper bank.

EXPERIENCES WITH THE NEW 1200-LB. TURBINE

The new 10,000-kw. high-pressure turbine also has given us many new experiences. When this turbine was put in service

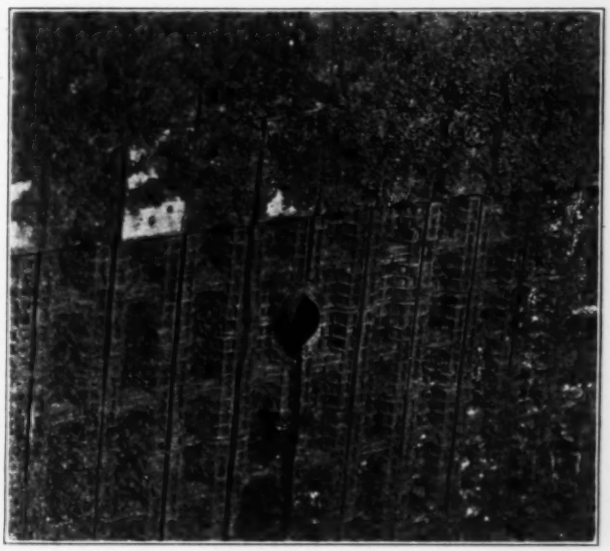


FIG. 9 RUPTURE OF REAR WATER-WALL TUBE, SHOWING LARGER OPENING WHICH OCCURS WHEN TUBES ARE COVERED WITH CAST-IRON WAFFLE BLOCKS. 1400-LB. BOILERS

it leaked badly at the horizontal joint in the casing. It was sent to the factory, where a large amount of metal was cut off the flanges to render them more flexible and to permit the use of shorter bolts. When it was opened up after a very few hours' service to have the flanges fixed, it was found that one bucket was gone from the last stage. The last four stages were re-bucketed with heavier buckets.

After these changes this turbine was again put in operation and has since operated satisfactorily. In the year 1928 this machine ran 3300 hours out of the possible 8784 hours, generating a total of 15,684,000 kw-hr. The exhaust steam from the unit generated approximately 60,000,000 kw-hr. in the 350-lb. machines. The low figures for running hours and kilowatt-hours for the high-pressure unit are primarily due to the development and repair work on the new boilers and stokers. The turbine was approximately 100 per cent available.

This high-pressure unit is equipped, as will be our third 1200-lb. unit, with a pressure governor which admits steam to the unit in sufficient quantity to maintain approximately 360 lb. pressure in the turbine exhaust. The load on the high-pressure turbine, therefore, is governed by the pressure in the low-pressure main, which latter is held constant also by the Bailey control for the low-pressure boilers. In the original design it was intended that the Bailey control on the low-pressure boilers should come into play after the high-pressure turbines were wide open. However, as the high-pressure part of our plant is not yet completely developed, we are setting the speed governor on this unit for the load which the high-pressure boilers can carry, allowing the low-pressure boilers to take the swings and maintain pressure. The pressure governor on the

present high-pressure unit is set at a pressure above that of the low-pressure main, and will function, in case of a sudden decrease in load on the normal-pressure part of the station, to shut off steam going through the high-pressure unit and prevent the reheater safety valves from blowing. The Bailey control on the fans of the high-pressure boilers maintains constant pressure on the high-pressure-steam main, and under the above conditions would tend to keep the high-pressure boilers from blowing. The bypass valve for this turbine is opened automatically either by the pressure governor when the 350-lb.-main pressure falls or when the turbine trips out.

EXPERIENCES WITH 1400-LB. BOILER-FEED PUMPS

As our experiences have been more varied with the second high-pressure boiler and turbine installation than with the first, so also have been our pump experiences, and since the new installation is of a different pressure than the old, we have not had the pumps of the original installation to fall back upon.

The pumps installed with the new 1400-lb. boilers consist of two units in duplicate, connected in series as shown diagrammatically in Fig. 10. The first is a 500-lb. unit taking hot water from the deaerator under low head. The water is first passed through a one-stage booster pump mounted on the shaft of the large pump. The large pump is a volute pump of five stages. The only trouble we have experienced with this unit has been hydraulic-thrust wear. This 500-lb. unit discharges water through heaters to a secondary pumping unit

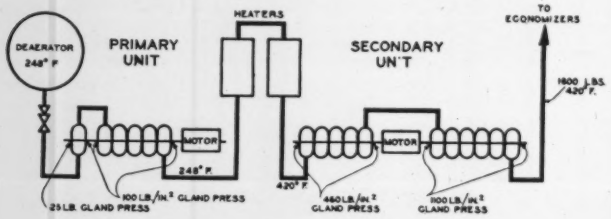


FIG. 10 SIMPLIFIED BOILER-FEED-PUMP SYSTEM, EDGAR STATION EXTENSION

consisting of a volute pump similar to the five-stage pump and a six-stage turbine pump. These two pumps comprising the secondary unit are mounted on opposite ends of a slip-ring-motor shaft.

We have experienced considerable trouble with these secondary pumps. The thrust plates have worn very rapidly, but we have been able thus far to run one pump long enough to allow us to repair the other and hold it in reserve for approximately two weeks before it is necessary to repeat the operation. In this manner we have been able to keep the plant in operation during our winter load. One of these pumps recently broke its shaft and caused considerable damage.

Shaft packing has also been a troublesome problem. Various kinds of metallic and other packings have been tried. Metallic packings which on lower-pressure installations have given satisfactory service have under our high-pressure conditions given only fair service. We have a high pressure extraction heater which takes steam from the exhaust of the high-pressure turbine. This heater in normal operation delivers water at approximately 420 deg. fahr. to the suction of the secondary pumping unit. This hot water accentuated our packing troubles, so we temporarily discontinued the use of the heater.

These pumps have been recently rebuilt by the manufacturer with larger shafts, Kingsbury thrust bearings, and labyrinth shaft packings. At the time of writing, the high-pressure heater is in service and the pumps are operating very satisfactorily.

In addition to these pumps we have a six-stage 3600-r.p.m. turbine-driven pump designed to deliver 900,000 lb. of water per hour at 1600 lb. per sq. in. This pump was originally intended to take water either from the yard storage reservoir at about 4 lb. pressure at 60 deg. fahr., or from the deaerator under approximately 25 lb. at 250 deg. fahr., or by means of bypassing the deaerator from the surge tank at 50 lb. pressure and 150 deg. fahr. No booster is used with this pump, and, although its operation is satisfactory when connected to either the yard storage reservoir or surge tank, it fails to operate when taking water from the deaerator. To correct this, several first-stage impellers were tried by the manufacturer without success. A great deal of trouble was encountered due to vibration, and the bushings in the pump seized on several occasions. This pump is largely for emergency use, and as such in taking water from the yard reservoir its operation would be considered satisfactory. However, since its cost is high, we should like to have it available as a spare for short periods while the other pumps are being overhauled. Under

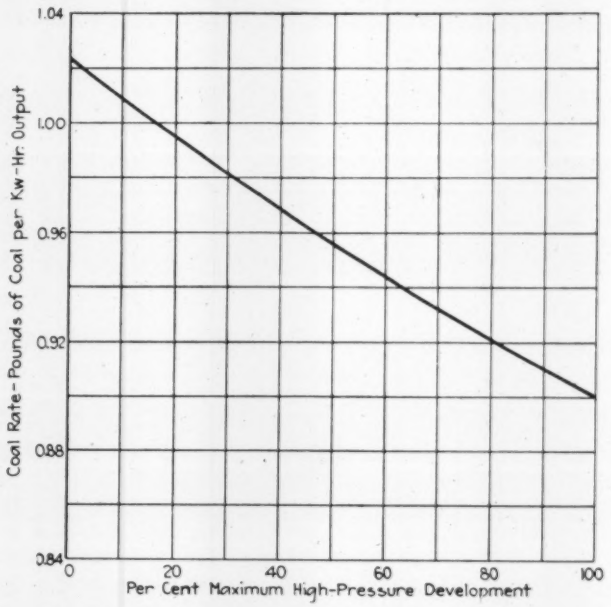


FIG. 11 RELATION BETWEEN COAL BURNED PER KILOWATT-HOUR AND PERCENTAGE OF MAXIMUM POSSIBLE HIGH-PRESSURE GENERATION

these conditions, cold undeaerated water from the yard reservoir or the surge tank would not be favorable to economy or safety. Therefore it is highly desirable that the pump should work satisfactorily under the normal operating conditions of the other pumps. The manufacturer feels that a first-stage impeller can be designed to function properly under these severe conditions, and is now carrying on development work for this purpose. While this is in progress we stand by with the pump connected to the reservoir ready for emergency service only.

During all of our pump trouble it was decided to reset the safety valves on the two 1400-lb. boilers to blow at the same pressure as the original high-pressure boiler, so that in case we lost all of our new high-pressure pumps we could feed across with the original high-pressure pumps and thus have additional insurance against burning our boilers. As a result of this arrangement we have a very high differential pressure across our boiler-feed valves, and consequently have been compelled to regulate the boiler feed by hand. As soon as our boiler pumps are operating satisfactorily, we shall return the 1400-lb. safety

valves to their original settings, use the feedwater regulators, and thus eliminate the danger from hand control.

Furthermore, it is difficult to obtain satisfactory boiler-feed pressure regulation with electrically driven feed pumps employing slip-ring motors. This is due to the fact that the head-capacity curve of a slip-ring-motor-driven pumping unit is very steep on account of the well-known speed-torque relation of the motor. This inability to slow down slip-ring motors is observed also to a slight extent with normal-pressure equipment. In high-pressure pumps, however, it is particularly noticeable.

STATION ECONOMY—POUNDS OF COAL PER KILOWATT-HOUR

The prime reason for advancing to higher pressures is because of the gain in economy. Fig. 11 shows the relation between the coal consumed per kilowatt-hour generated and the percentage of maximum possible high-pressure generation. It will be noted that the coal consumption of the 350-lb. part of the station under the prevailing conditions represented by the chart is about 1.02 lb. per kw-hr., and that there is a gain of 12 per cent with the use of high-pressure equipment to the full extent or when the normal-pressure units are supplied entirely by high-pressure-unit exhaust. The coal burned is New River semi-bituminous and has a calorific value of 14,050 B.t.u. per lb. as fired. Our equipment at Edgar Station is a partial development, so that the fuel consumption of the station should fall only part way down the curve.

After making allowances for the lack of availability of boilers due to boiler, stoker, and pump developments and to other unavoidable operating factors, the fuel-consumption figures fall surprisingly close to the line and confirm the expectation which has been entertained with regard to the high-pressure gain.

CONCLUSIONS

A close study of the troubles experienced always gives an unfavorable impression of any installation. In general, however, all new departures are certain to be attended by small difficulties which require correction, but in this respect high-pressure steam has not developed any difficulty that was not readily taken care of. It is therefore our conclusion that high-pressure steam for electric power generation is entirely practical and with regard to efficiencies is meeting, and will continue to meet, the expectations of the designers.

High-Pressure Steam Plants—The American Viewpoint

BY A. R. SMITH,[1] SCHENECTADY, N. Y.

DURING the past several years there has been an insistent demand for higher thermal efficiencies in steam-electric power plants, and there has been a persistent endeavor on the part of engineers to accomplish this by resorting to higher steam pressures and temperatures. Realization of improved economies was bound to be the result of such a situation.

As the pressures employed are increased, the percentage improvement in efficiency diminishes, so that great care has to be exercised in balancing the reduction in fuel cost against the increase in fixed charges. Now, however, it looks as if we might shortly be able to construct a high-pressure steam plant at the same cost as a lower-pressure plant, which would leave the fuel saving a net gain.

The cost of apparatus of special design must necessarily be high, but once such apparatus comes into general use the cost is materially reduced. This condition was exemplified in the increase from 200 to 400 lb. steam pressure, because it was the opinion at that time that the 200-lb. plant represented the lowest investment, whereas the 400-lb. steam plant today should be the most economical one to construct even though the fuel cost were almost negligible. It is therefore reasonable to expect that ten years hence the plant showing the minimum investment may be one for 600 or 1200 lb. steam pressure.

At first we were somewhat concerned about the safety and reliability of high steam pressures, just as we were not many years ago concerned about the hazard of high voltage. High-pressure steam, like high potential, requires different standards of manufacture and operation, but once these standards become general knowledge there is no reason why a high-pressure steam plant cannot be operated with the same degree of safety and reliability as a low-pressure one; in fact, the high-pressure steam boiler may ultimately be less of a potential hazard than the low-pressure boiler.

The papers by Messrs. Moultrop and Havlíček in this issue do not treat with theoretical possibilities, as the economies have been generally recognized for some time; instead they illustrate the problems encountered in real commercial service. Within the next year or two there will be in operation several 1200-lb.-pressure plants of large capacity, from which further important information will be obtained.

Unfortunately the pioneers in any new development are allowed to work out their problems pretty much alone, and others delay following their example until the greater difficulties have been solved. Troubles and disappointments on any new development usually come in series, which greatly delays the commercial development of any particular enterprise, but if several installations were made along somewhat different lines many minds would be at work simultaneously on similar problems, and troubles would be encountered and remedied in multiple, which would result in more rapid progress. With such a program the development might be somewhat more costly to the individual companies, but it would be economic from the standpoint of advancement in the art.

It is interesting to note that both authors are proposing to resort to more complete automatic control, and it is obvious that with greater outputs, lower temperature differentials, reduced water storage, etc., complete, reliable automatic control is very likely to have considerable bearing on the success of the modern high-pressure plant where materials are worked so intensively.

* * *

IS THE thermal circulation in standard types of boilers so poor at these pressures of 1200 lb. and 1400 lb. as to necessitate a complete change in design? Mr. Moultrop says no. However, our European contemporaries reason from the same published results that forced circulation must be resorted to for 1400 lb. pressure and above. The trend of development at Edgar Station is certainly toward forced circulation. Boilers Nos. 7 and 8 have 39.6 per cent of the steam-generating surface subject to thermal circulation in the boiler and water walls. The remaining 60.4 per cent is subject to forced circulation in the steaming economizer.—C. W. Gordon, M.E., Superheater Co., New York, N. Y. (Mem. A.S.M.E.), in discussion of paper by I. E. Moultrop—see page 259.

[1] Engineer, Construction Engineering Department, General Electric Co. Mem. A.S.M.E.

The Use of High-Pressure Steam in Europe in Economic Power Generation

By PROFESSOR DR. S. LÖFFLER,[1] BERLIN, GERMANY

ECONOMIC power generation in Europe has for a long time been based on the heat of coal and operation with steam. Large modern stationary plants, however, are concerned more especially with the generation and use of electric current. Numerous central stations throughout the country provide for the widespread distribution of electrical energy, which, in the future, will regulate the technical life of all mankind.

For the most part, reciprocating steam engines, and particularly steam turbines, are used to drive the large electric generators. They are also employed for the direct drive of such machines as pumps, compressors, etc., and particularly on locomotives and in the propulsion of ships.

Economical steam operation demands the use of high pressures and temperatures. This has been known in Europe for many decades. Perkins in England and Dr. Alban in Germany sought to utilize a pressure of 1420 lb. early in the nineteenth century. But at that time there were no materials which could withstand such high pressures, and particularly temperatures of many hundreds of degrees fahrenheit. For this reason steam pressures had risen very slowly to only 220 lb. at the beginning of the twentieth century, though occasional attempts had been made to use much higher pressures.

In recent years, however, the practical work of Laval and of Wilhelm Schmidt has given a new and forceful impetus to high-steam-pressure operation, which was mentioned at the high-pressure session of the V.D.I. in 1924. It was not attempted at first to use pressures in excess of 500 lb. because it was rightly feared that the generation of high-pressure steam in the old types of boilers would prove unsafe. In addition, it was believed that high-pressure boilers and engines would cost too much and, especially in the case of condensing plants, that their operation would be unprofitable.

Boilers of the ordinary type use soft steel for their tubes, headers, and drums. This steel is affected unfavorably during operation, and its limited strength at the yield point is sharply reduced, especially at high temperatures. Therefore all parts of such boilers made for high-pressure operation have to have thick walls, and accordingly are very expensive.

More important, however, is the fact that high superheat temperatures cannot be obtained with such boilers because occasional rises of temperature of around 212 deg. fahr. and more cannot be prevented, and because the superheater tubes, especially when firing up the boiler or when unloading it suddenly, are endangered. For this reason, until now only temperatures of from 660 to 750 deg. fahr. have been employed, at which relatively low temperatures an increase of the steam pressure beyond 700 lb. is not advantageous.

When the operating steam temperature is raised above 840 deg. fahr. (or if possible above 930 deg.) an increase of the pressure up to 2200 lb. is very economical even with condensing steam plants. It is still more so in industrial power plants, where in addition to generating electric current, steam is used for cooking and heating, as in textile, paper, and sugar mills and in many chemical works, as well as for the heating of factories and dwellings.

When working with pressures above 1420 lb. and temperatures in excess of 950 deg. fahr., positive control and absolute safety are imperative. These cannot be obtained with the old boiler types, which, in addition, when used for high pressure can rarely be operated at a profit. However, in recent years new boiler systems have been developed which are particularly suitable for the generation of steam at very high pressures and temperatures, and which can be positively controlled, with absolutely safe operation guaranteed.

In one of these new boilers, the Löffler, superheated steam is forced into the water in an evaporator drum by a pump, and the steam generated in this way is run through a radiant-heat superheater and then pumped to the turbine. By regulating the number of revolutions of the pump, the boiler can be adapted to every change of the fire, water, load, and steam temperature. When using ordinary boilers which for high pressures must be built very high (up to 130 ft. and more) so that the water will circulate with sufficient velocity, the steam will enter the superheater very wet and dirty, the more so the greater the velocity of the water circulation. With the Löffler boiler, however, the steam has to flow only a very short distance through the water, and therefore has no opportunity of taking up much moisture and impurities, but arrives quite dry and clean at the superheater and the engine.

The steam always flows through the superheater of the Löffler boiler, so that when firing up the boiler or when throwing off the load on the engine, a supply is assured at all times. All parts of the boiler can be made from hard steel, which retains its strength even at very high temperatures. The steam pump for the larger boilers is of the centrifugal type, and is therefore small, simple, and cheap. This pump has been found reliable, and at steam pressures above 1420 lb. and full load it requires for its operation less than two per cent of the power generated by the boiler operating condensing.

The positive control of the flow and temperatures in the Löffler boiler permits locating the superheater so that it is exposed to the full radiation of the fire. The heating surfaces are therefore small and inexpensive. The boiler drums can be placed on the floor, without making heavy framework necessary. For these reasons, a Löffler boiler for 1850 lb. and 932 deg. fahr. will not cost more than an ordinary boiler for 500 to 550 lb. and of the same capacity. Under these conditions, high pressure is of greatest importance also in condensing power plants. It is much more economical to increase the pressure at once from 210 lb. to 1400 lb. or more than to only 500 lb.; for with an increase of the pressure to 500 lb. the fuel economy obtained is about 15 per cent and the investment cost is about 30 per cent higher, but when increasing the pressure at once to 1420 lb., raising the temperature at the same time to 842 deg. fahr. or higher, and using an intermediate superheater, twice as high a fuel economy can be obtained without any considerable increase in the investment cost when using the Löffler boiler.

The large number of steam power plants for 500 to 710 lb. pressure which have been built in all countries, and especially in Germany, during the last few years show that an enormous importance is attributed in Europe to high-pressure operation. There are also several plants for pressures over 1420 lb. partly built or in operation, using ordinary boilers, and also new boiler systems such as the Schmidt, Benson, and the Löffler. Tests thus far made on these plants betoken the rapid development of high-pressure operation.

[1] The Berlin School of Technology (Technische Hochschule).

(Continued on page 274)

The High-Pressure Steam-Electric Plant of the Witkowitz Collieries, Czechoslovakia[1]

Particulars of the Pulverized-Coal-Fired Löffler Boiler Installed for Generating 40,000 Lb. of Steam per Hour at 1700 Lb. Pressure and 932 Deg. Fahr.; of the 18,000-Kw. Erste Bruenner Turbine; and of Operating Experiences From November, 1927, to Date

By JAROSLAV HAVLIČEK,[2] MORAVSKA OSTRAVA, CZECHOSLOVAKIA

IN 1925 it was decided to enlarge the electric power plant of the Karolinen shaft of the Witkowitz collieries in Moravska Ostrava and to operate it with high-pressure steam. After studying the various types of steam generators available, the Löffler boiler, which was designed along entirely new lines, seemed to offer far greater safety of operation than any other design which had been made and tested up to that time. However, a number of questions arose: namely,

1 Whether the heat transmission from tubes to saturated and superheated high-pressure steam was sufficiently great to secure, with moderate heating surfaces, a supply of steam without the necessity of having too great a difference in temperature between the tube walls and the steam;

2 Whether the rate at which the superheated steam gives up its heat to the water during its flow through the latter, is sufficiently rapid, and whether it is possible to generate as much steam per unit of water surface as in the older types of heavy-duty boilers;

3 Whether the capacities of the feedwater pump and the circulating pump required for circulating the steam in the boiler system, are not too great and do not thereby unduly decrease the efficiency of the boiler;

4 Whether the design of the circulating pump is such as to assure continuous operation over a long period, particularly with reference to the stuffing boxes, which have to be tight under 1700 lb. per sq. in. pressure, and to its unlubricated piston working in saturated steam;

5 Whether the pipe coils in the boiler drum can be made from ordinary, inexpensive material without the necessity of resorting to an unusual and therefore expensive one;

6 Whether the autogenous welding of the tubes, including those which are surrounded by flame, is dependable, and whether for an extended period the welds can be made to resist the temperatures and effects of the flue gases on the one hand, and those of the steam on the other;

7 Whether the flanges will remain thoroughly tight for a long time and whether the necessary pipe fittings, such as valves, water-level indicators, etc., can be produced without elaborate and costly experimentation; and finally,

8 Whether the Löffler boiler can be so designed as to simplify fabrication and installation, and whether it can compete as to price with other designs for equal pressures and temperatures.

Early in February, 1925, at the Vienna Locomotive Works, the author thoroughly examined the first Wiener Lokomotivfabrik experimental Löffler boiler, which was designed to generate about 660 lb. of steam per hour at 1420 lb. per sq. in. pressure and 932 deg. fahr., and found that it answered the foregoing eight questions satisfactorily; consequently nothing stood in the way of placing the order for the high-pressure installation three months later.

During the same period, long-run tests were made of the new turbine designs of the Erste Bruenner Maschinenfabrik which attain the highest possible efficiency through the use of very low steam velocities in the blades of the rotors. Of course the turbines had to be made much longer in order to accommodate a much greater number of wheels than were used in the old designs, still the lower rate of steam consumption per kilowatt-hour has amply compensated for the higher cost of the turbine.

A steam turbine designed for 18,000 kw., 3000 r.p.m., 1700 lb. per. sq. in., and 932 deg. fahr. was ordered from the Erste Bruenner Maschinenfabrik, and a Löffler boiler, designed for 39,600 lb. of steam per hour at the same pressure and temperature and to be fired with pulverized coal, was ordered from the Witkowitz Iron Works, both Czechoslovakian concerns.

This 18,000-kw.-capacity turbine requires about 132,000 lb. of steam per hour. It was decided to first build a boiler for generating 39,600 lb. of steam per hour, and only after extended tests to proceed with the construction of the others needed. This made it necessary to continue the operation of the existing 210-lb. boiler installation, and for this reason the turbine was designed as a two-pressure machine with steam pressures of 210 and 1700 lb. per sq. in. The valve gear of the turbine was so arranged that all the steam generated in the high-pressure boiler would be used first, after which low-pressure steam from the existing 210-lb. boilers would be admitted as the load required. Later the turbine is to work either with 1700-lb. steam alone or in combination with about 33,000 lb. of 210-lb. steam from the waste-heat plant of a near-by cokery. The turbine section for 210 lb. pressure was put in operation in December, 1926, the high-pressure boiler in July, 1927, and the high-pressure section of the turbine at the beginning of 1928.

Thermal Scheme of Plant

The plant was to be so constructed as to give the highest possible economy, making use of all the improvements known at the time. The old boiler plant of the station consists of five Garbe boilers each having 6456 sq. ft. of heating surface and provided with traveling grates for firing with waste coal from the company's mines and the near-by coke plant. There is no economizer. The waste coal consists of sludge from the coal-washing plant, which after air drying still contains 25 per cent of water, and of screenings running under 0.4 in. A mixture of these two gives a fuel having a 15 per cent moisture content and a 25 per cent ash content. Its calorific value in the dry state ranges from 10,500 to 11,500 B.t.u. per lb.

After the high-pressure plant has been completed, the low-pressure Garbe boilers will serve only as reserve capacity. It was therefore thought desirable to utilize one of them as an economizer for the new high-pressure boiler. This novel arrangement was effected by changing the water circulation somewhat by constructing partitions in the Garbe boiler.

The condensate from the turbine is used as feedwater in addition to water from a distillation plant. The distillation plant, of the Neumann system, employs steam from the low-pressure (210-lb.) boiler plant and a heat pump. The distillation takes

[1] Translated by the Engineering Index Service Staff.

[2] Formerly Professor in Ordinary at the Royal University, Zagreb.

place at atmospheric pressure, and a quarter of the weight of the water distilled is used for live steam. The steam leaving the distilling apparatus is condensed by the condensate from the turbine, and thus the heat of the live steam used in the distilling process is recovered, and the temperature of the condensate raised 12.5 deg. fahr. The feed pump of the low-pressure plant and the turbine condenser are driven electrically and do not enter into the heat account of the plant.

In the high-pressure plant the condensate is heated, by means of steam bled from the turbine, to about 248 deg. fahr. in one stage, and intermediate superheating of the turbine steam is effected at a pressure of around 210 lb. per sq. in. This takes place in a heat exchanger directly under the turbine with high-pressure steam of 1700 lb. per sq. in. and 932 deg. fahr. which is condensed to water at 1700 lb. per sq. in. and 612 deg. fahr. This hot water is forced back to the high-pressure boiler by means of a small centrifugal pump. In the near future steam at a pressure of 70 lb. per sq. in. will be bled from the second stage for long-distance steam-heating service. Not more than 44,000 lb. per hour can be supplied, and this is to be returned to the plant as condensate at a temperature of about 158 deg. fahr. The circulating pump of the first Löffler boiler is of the plunger type and is driven by a three-phase commutator motor, the speed of the pump being regulated by shifting the brushes of the motor. Electric drive was chosen so that the power requirements of the circulating pump might be measured without inconvenience at various operating conditions, and so that experimental data for further high-pressure boiler construction might be collected. The feed and circulating pumps of the new boilers will be of the centrifugal type. They will be driven by turbines using steam at 210 lb. per sq. in. pressure and 662 deg. fahr. The exhaust will be used for heating the condensate from the turbine and the feedwater. In the heat balance of the plant, the steam drive will be taken into account. The power required for condensing purposes, for the feed pump of the 210-lb. boiler plant, for drying the coal, and for grinding and transporting the pulverized coal,

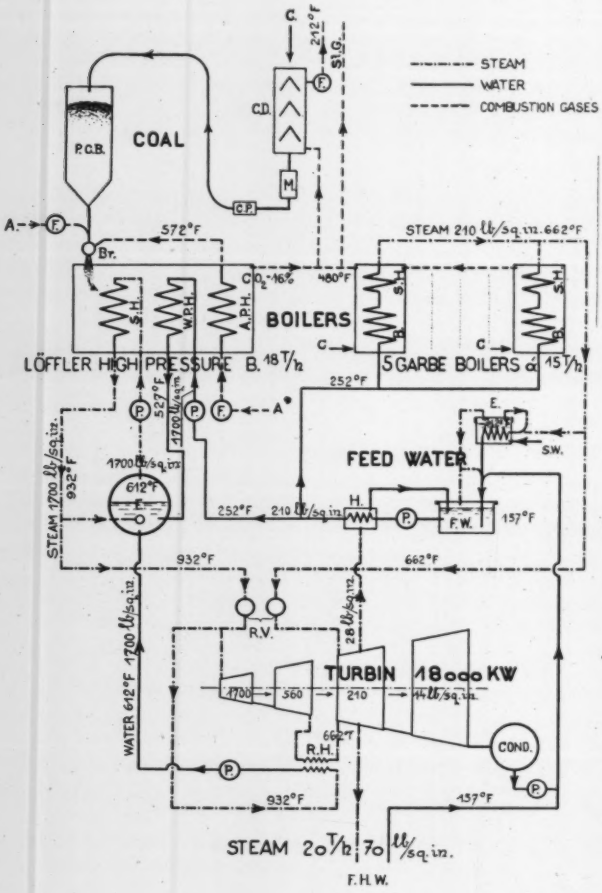


FIG. 1 SCHEME OF HIGH-PRESSURE PLANT OF THE WITKOWITZ COLLIERIES

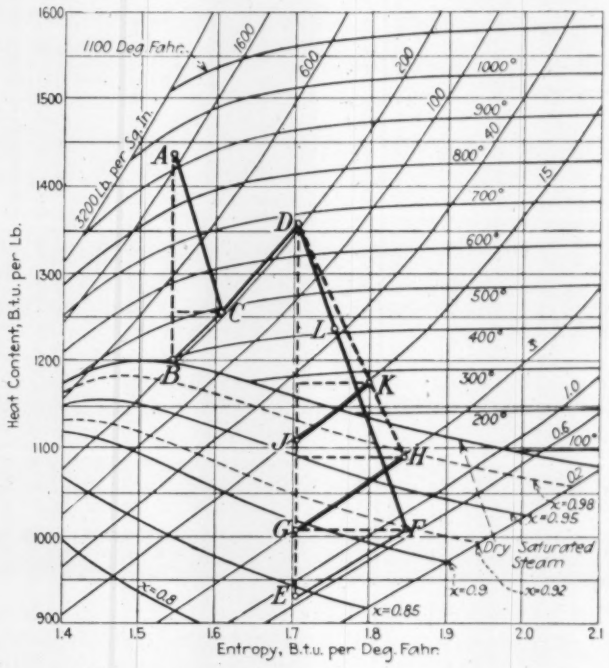


FIG. 2 MOLLIER DIAGRAM FOR MAKING COMPUTATIONS

as well as the power for the various small auxiliary drives of the boiler house, will be considered as useful load in the heat balance. The power thus required is as much as in other plants, and will be obtained from the electric power generated. From the foregoing it will be easy to make the desired computation from the heat-balance data. Fig. 1 shows the scheme of the plant, Fig. 2 is a Mollier diagram for making the computations, and Fig. 3 a heat-consumption diagram. From a study of these figures the following interesting relations will appear: The thermal states *A*, *C*, *D*, *F* in the Mollier diagram of Fig. 2 give the working conditions of the turbine with bleeding at *L* for heating the condensate. The thermal states *D*, *K*, *H* correspond to the working conditions of the small turbine for driving the feed and circulating pumps. Fig. 3 shows the heat consumption per pound of steam corresponding to these thermal states. In this the power required for the feed and circulating pumps of the high-pressure plant, which is figured as loss, is also considered.

According to the determinations for the first Löffler boiler the energy requirement of the circulating pump per pound of steam generated at full load is equal to 9.6 B.t.u., and of the feed pump, 9.6 B.t.u., or 19.2 B.t.u. in all, the efficiency of both pumps being taken as 65 per cent. From Fig. 3 the thermal efficiency of the steam drive at the coupling of the turbine is seen to be as follows:

(1) Taking into account the feed and circulating pumps,

$$\frac{\text{Useful work of 1st and 2nd turbine stages}}{\text{Heat } abcd + efgh} = 36.8 \text{ per cent}$$

(2) Taking only into account the circulating pump the value in (1) rises to 37.6 per cent.

Efficiency of boiler = 87 per cent, approx.

Efficiency of generator = 95 per cent, approx.

Heat requirement in coal per kilowatt-hour at the switchboard:

$$\text{For (1)}, \quad \frac{3370}{0.368 \times 0.86 \times 0.95} = 11{,}000 \text{ B.t.u.}$$

$$\text{For (2)}, \quad \frac{3370}{0.376 \times 0.87 \times 0.95} = 10{,}800 \text{ B.t.u.}$$

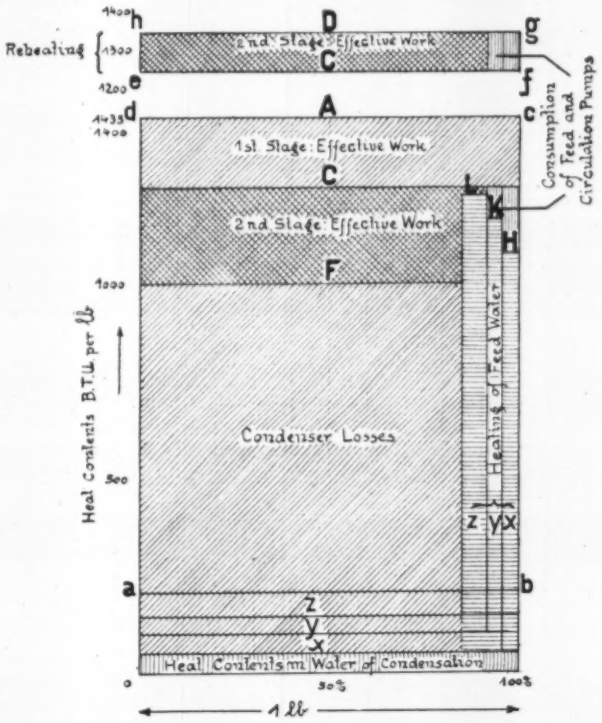


FIG. 3 HEAT-CONSUMPTION DIAGRAM OF PLANT
(A-L: Heat conditions according to Mollier diagram, Fig. 2.)

DESIGN AND ARRANGEMENT OF BOILER

The Löffler boiler has been described frequently in the technical press (e.g., *Power*, December 29, 1925) and therefore the principle of steam generation which it employs will be only briefly considered.

Referring to Fig. 5, evaporation is effected in evaporators or drums *A* which are not exposed to flame and are half-filled with water. From these saturated steam is pumped out and forced through a radiant-heat superheater *B* situated in the combustion chamber and a resuperheater *D* in the first duct of the furnace. Here the steam is raised from the temperature of saturation to the desired superheat temperature of 932 deg. fahr. About one-third of the pumped steam goes to the turbine; the remainder returns to the evaporator, where it is discharged through perforated pipes under water, with which it mingles, giving up its superheat to the water, which, already heated to the saturated-steam temperature, evaporates in proportion to the amount of superheat. Thus the evaporation is indirect. Boiler scale is likely to be deposited in the evaporator, but the tubes of the superheater remain clean. The feedwater is delivered through a feed pump to an economizer *E* situated in the second duct of the boiler, where its temperature is raised from 252 deg. fahr. to about 572 deg. fahr. The dimensions of the economizer are such that the end temperature of the feedwater remains definitely a few degrees below the saturated-steam temperature, so that no water is evaporated in it. Deposition of boiler scale in the economizer is thus avoided, and its walls also remain permanently clean.

The boiler is started up by heating the water in the evaporators by means of steam from the low-pressure (210-lb.) steam plant, after which the circulating pump is set in motion and the burners lighted. At first all the superheated steam, at 932 deg. fahr., is blown into the evaporator under water. The water is then evaporated in proportion to the heat delivered by the superheated steam, and as soon as the pressure reaches the desired point the feed pump is set in motion and the steam generated is delivered to the turbine.

Fig. 4 gives the curves of pressure, superheat, revolutions of the pump, and other data pertaining to the starting process. The starting takes about two hours, but this could be reduced by from 20 to 30 minutes if the steam for heating up the evaporator were taken from a high-pressure boiler instead of from a low-pressure one.

The boiler installation is shown in Figs. 5, 6, and 7. It consists of five evaporators (*A*) 800 mm. (31.5 in.) in diameter and 7000 mm. (22 ft. $9\frac{1}{2}$ in.) long, a radiant-heat superheater (*B*) in the combustion chamber (*C*), a resuperheater (*D*) consisting of nine tubes bent in the form of a figure 8 which are connected in parallel, an economizer (*E*) consisting of nine similarly shaped and similarly connected tubes, and an air preheater (*F*). The tubes of the radiant-heat superheater have an inside diameter of 44.5 mm. (1.75 in.) and an outside diameter of 63.5 mm. (2.5 in.); those of the resuperheater have an inside diameter of 55 mm. (2.17 in.) and an outside diameter of 76 mm. (3 in.), while the tubes of the economizer have an inside diameter of 40 mm. (1.58 in.) and an outside diameter of 51 mm. (2 in.)

The material of the evaporator drums is Siemens open-hearth steel of a strength of 60 kg. per sq. mm. (85,000 lb. per sq. in.),

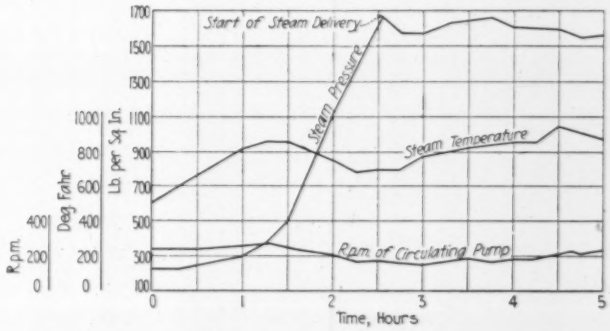


FIG. 4 CURVES OF STEAM PRESSURE, TEMPERATURE, AND R.P.M. OF CIRCULATING PUMP DURING STARTING PERIOD OF LÖFFLER BOILER

and having an elongation of 18 per cent; the tubes are of Siemens open-hearth steel of a strength of 55–60 kg. per sq. mm. (78,000–85,000 lb. per sq. in.) and an elongation of 20 per cent. All the pipe joints, whether or not exposed to flame, are welded by the autogenous method and subsequently annealed. The use of costly special steels and alloys is quite unnecessary.

The construction of all parts is made as cheap as possible. The evaporators are made as follows: A smooth drum shell is forged and turned in a lathe to the proper wall thickness. The ends are heated and strong heads are screwed in, the pipe shrinking on the heads as it cools. To lighten the strain on the pipe ends, strong shrink rings are slipped on hot over the pipe where the heads are

screwed in. All the pipe connections for saturated-steam, superheated steam, feedwater, etc., as well as the manhole for admission into the evaporator for the purpose of cleaning it, are arranged in these thick, flat heads. The drum itself has no openings. The stop valves are of an original Löffler design. The body is made of a solid forged steel block and the pipe connection is welded in.

The throttle valves are so shaped that throttling occurs at a predetermined position of the throttling cone and not at the seat and packing surfaces of the valve. Because of this the seat surface stays clean and tight. The valve cones and throttling parts are made of stainless steel.

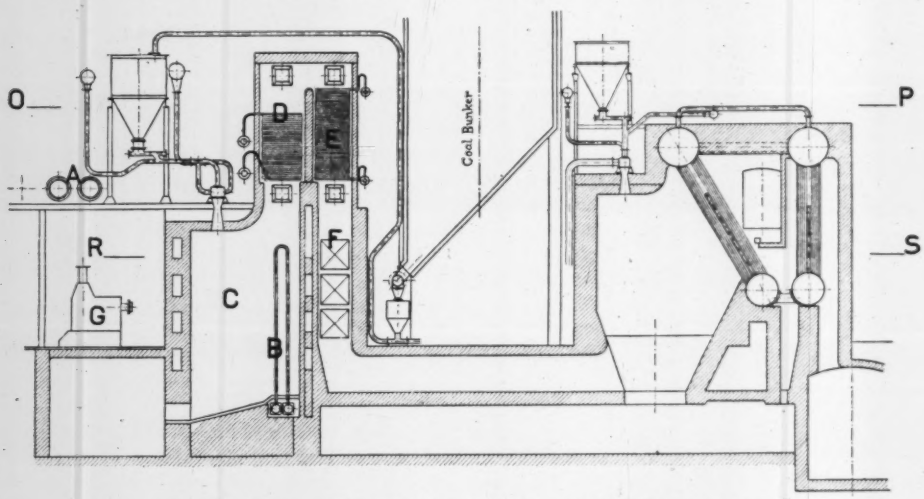
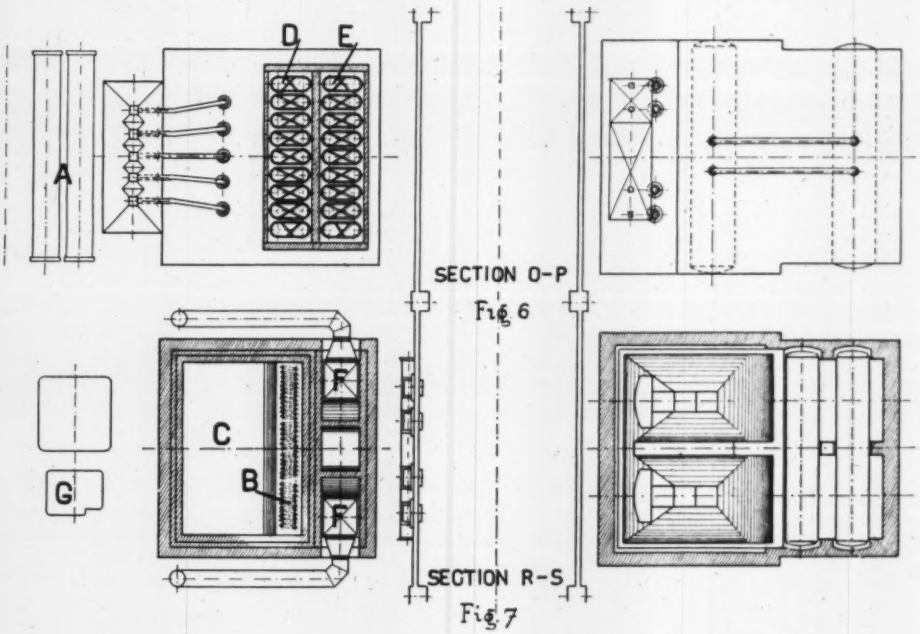


FIG. 5 SECTIONAL ELEVATION OF LÖFFLER BOILER INSTALLATION

The external pipes, valves, evaporators, the cylinder of the circulating pump, and the turbine cylinder are insulated with spun glass.

In the superheater and the economizer the heat transfer from the walls to the superheated steam and to the water depends on the velocities of the steam and of the water in the tubes. These are so chosen that in the Löffler boiler the heating surface, including that of the superheater and the economizer, is no greater and is even less than that of heavy-duty boilers of other systems.

Figs. 8–12 show views of the Löffler boiler and its various parts.



FIGS. 6 AND 7 HORIZONTAL SECTIONS OF LÖFFLER BOILER SHOWN IN FIG. 5

The circulating pump and the feed pump of the 39,600-lb.-per-hour boiler are of the plunger type, the cylinders and valve chests being made of a forged steel block. Both pumps have two cylinders each with a common connecting rod which is driven by a 260-kw. electric motor having a crankshaft with two cranks, one set 90 deg. ahead of the other. The drive of the feed pump is so arranged that during operation the stroke can be changed by hand or automatically. The feed is continuous. The plunger of the feed pump, as well as the cylinder of the circulating pump, is not lubricated. The feed pump is lubricated by the water it pumps, while the circulating pump is lubricated by the saturated steam which it handles.

Until recently the stuffing box of the circulating pump was packed with tightly twisted graphitized asbestos rope impregnated under pressure with oil of high flash point, and had to be renewed after a comparatively short period of service. For this reason the stuffing boxes are now provided with spring-ring packing which has to be copiously lubricated, and which has proved satisfactory during a long period of testing.

The connections of those pipes which have to be broken for inspection of the boiler and the circulating pump are made by means of flanges to which the pipes are welded. These flanges have a metal-to-metal joint, and no packing is used. Wherever possible, flanges were dispensed with and pipe connections were made by means of autogenous welding.

FIRING WITH PULVERIZED COAL

Waste coal from the coke plant, sludge from the coal-washing plant, which is very high in ash content, and pulverized coal are used for firing. The ash content of the fuel is about 25 per cent and its calorific value is from 10,800 to 11,160 B.t.u. per lb. The moisture content of the mixture of wet sludge and pulverized coal is reduced from 15 per cent to 1 per cent by drying with waste gases of the boiler plant in a drier manufactured by Huillard & Mourgeon, of Paris, after which it is ground in Fuller mills to a fineness corresponding to a residue of 12 per cent on a 180-mesh screen. At present the drying and grinding installation is designed for a capacity of 11 tons per hour, which rate can be doubled.

The pulverized coal is stored in large concrete bunkers, from which it is delivered into the bin just above the high-pressure boiler (Fig. 5). The transportation is effected by means of Fuller-Kinyon pumps.

The boiler is served by five Witkowitz Löffler burners, each capable of burning 1320 lb. of coal per hour, and which are similar in their operation to bunsen burners. The pulverized coal is delivered to the burner with cool air through a pipe in the middle of the burner; the secondary air, which is preheated to a temperature of from 572 to 662 deg. fahr., is supplied in the space surrounding the pipe through which the coal is fed. The coal-air mixture entering the combustion chamber is ignited directly back of the burner.

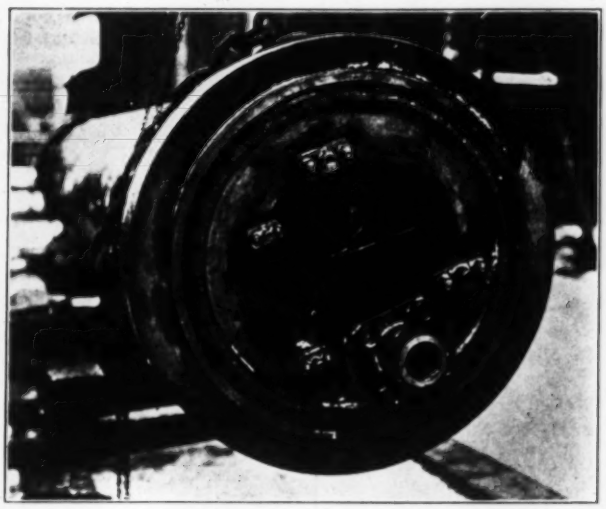


FIG. 8 FRONT HEAD OF EVAPORATOR, SHOWING FLANGES FOR PIPE CONNECTIONS

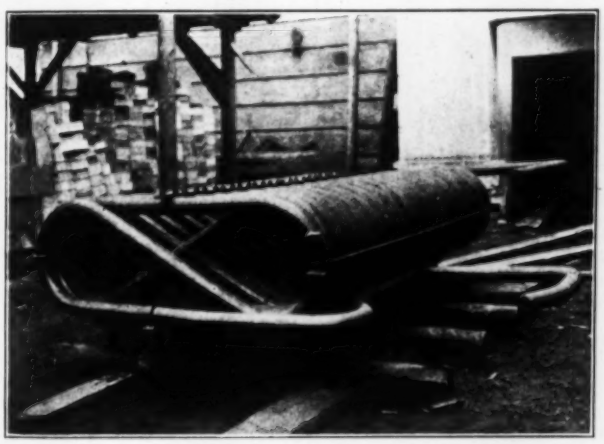


FIG. 9 SUPERHEATER COIL

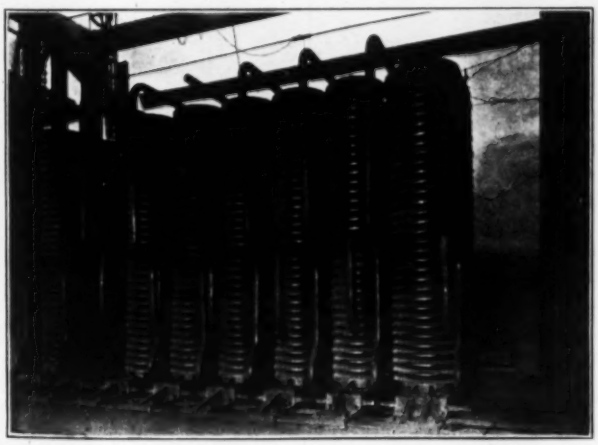


FIG. 10 ARRANGEMENT OF SUPERHEATER SECTIONS IN BOILER FRAME

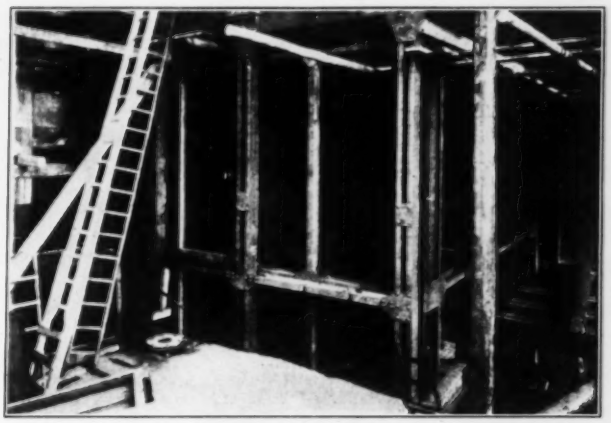


FIG. 11 RADIANT-HEAT SUPERHEATER IN POSITION

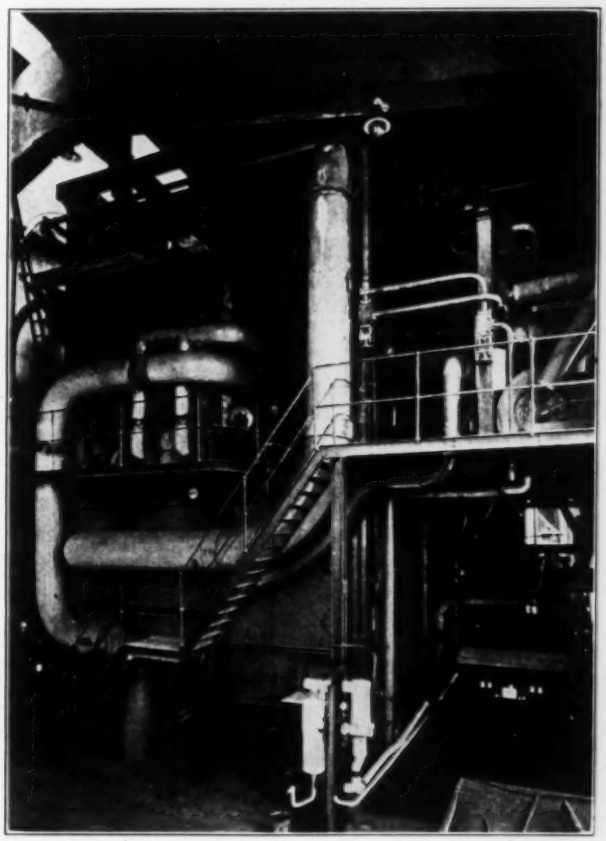


FIG. 12 GENERAL VIEW OF LÖFFLER BOILER

Coke gas is also available from a cokery located near by, and is burned by the same burner that burns the pulverized coal. When starting up, the boiler is first heated with coke gas, then pulverized coal is gradually supplied and the gas supply shut off. The burners have proved very satisfactory with the high air preheat mentioned and bring about complete combustion of the fuel in spite of its high ash content and high percentage of CO_2. The combustion chamber with the radiant-heat superheater built in it is shown in Figs. 13 and 14.

So far as the author knows, the setting of a radiant-heat superheater directly in the flame of the combustion chamber, without any protective arch, as done in the Löffler boiler of the Karolinen shaft, is the first successful attempt of the kind. This success is the more significant, since the tubes carry not water but steam. But this is possible only because of the positive steam flow peculiar to the Löffler system, which insures an absolutely safe heat control over the tubes. This experience will be utilized to a still greater extent in the two new boilers of 88,000 to 110,000 lb. capacity per hour which are now in course of construction. At the same time the burner design will be tested with air preheated up to 932 deg. in an experimental combustion chamber.

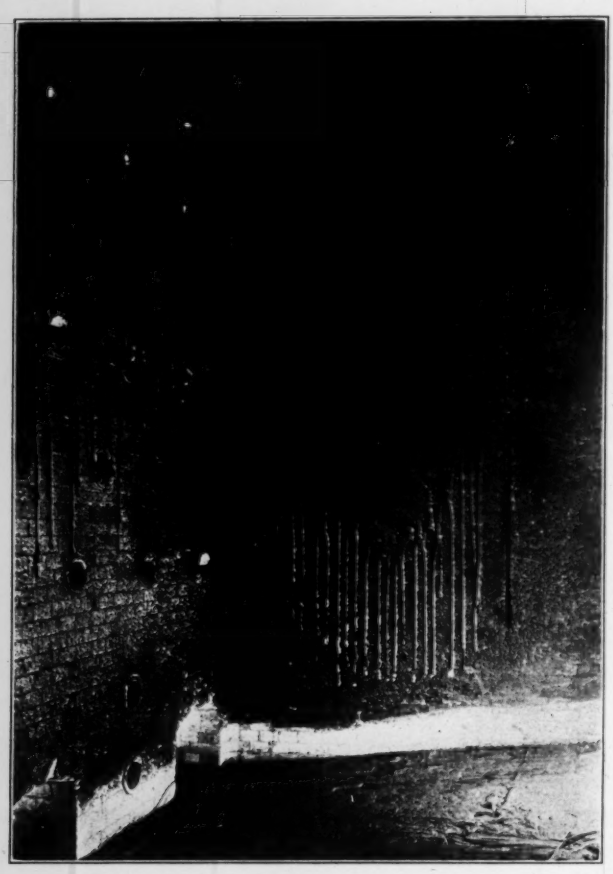


Fig. 13 Combustion Chamber After a Considerable Period of Use

The walls of the new combustion chambers will be made practically only of tubes. There will be no mass of firebrick to continue to radiate after the boiler is shut off. The new boiler design will follow all the changes in firing. The boilers will be equipped with an automatic device which will regulate the number of revolutions of the circulating pump and the feed pump, as well as the supply of pulverized coal and air in accordance with the steam pressure in the boiler, the rate of taking out steam, the superheating of the steam, and the CO_2 content of the flue gases. In addition, the automatic device will keep the feedwater at a constant level in the boiler.

A perfectly automatic regulation of the boiler is aimed at for the sake of maintaining the highest possible efficiency without depending on the watchfulness of the attending personnel.

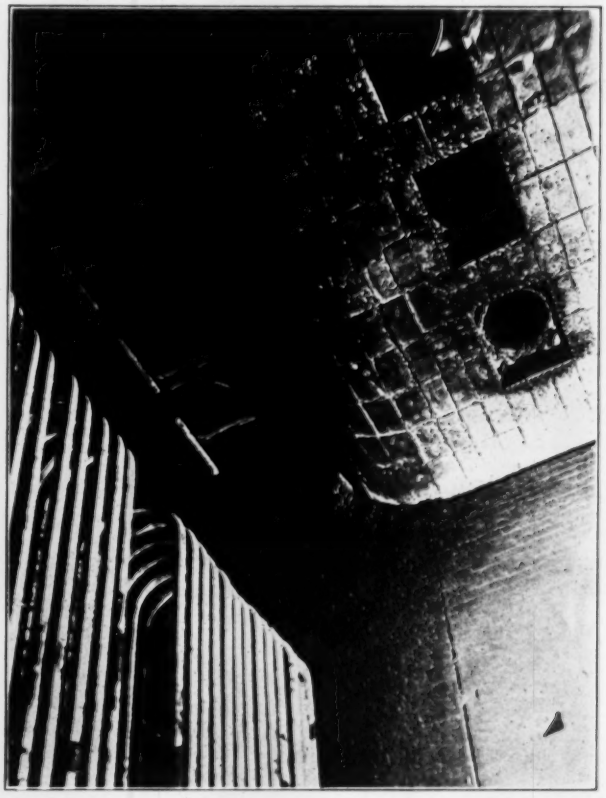


Fig. 14 Radiant-Heat Superheater and Burner. View From Below After a Considerable Period of Use

The Turbine

The capacity of the turbine is 18,000 kw. It utilizes the drop in heat from a pressure of 1700 lb. per sq. in. to a vacuum of 0.7 lb. per sq. in. in four stages: namely, at full load, in the first stage, from 1700 to 560 lb. per sq. in.; in the second stage, from 560 to 210 lb.; in the third stage, from 210 to 14 lb.; and in the fourth stage, from 14 lb. to 0.7 lb. Between the second and third stages the steam, which has passed through the first two stages, is reheated by means of high-pressure steam to a temperature of 662 deg. fahr. The fourth stage is designed for double flow. The exhaust from this stage is led by means of four pipes to a condenser set under it and at right angles to the axis of the turbine. The bleeding points for industrial steam of from 42 to 70 lb. pressure and for the heating of condensate at from 28 to 42 lb. pressure are located in the third stage.

The quantity of steam flowing through the turbine at full load amounts to from 130,000 to 155,000 lb. per hour after bleeding.

The capacity of the first and second stages is about 6000 kw., and that of the third and fourth stages 12,000 kw., or a total of 18,000 kw. The wheels of the four stages are mounted one after the other on a shaft and are coupled with each other and with the generator; the number of revolutions per minute is 3000. The drop in heat per stage is, in accordance with the design of the

Erste Bruenner Maschinenfabrik, only a few B.t.u. in order to obtain the greatest possible economy, and as a result the turbine is of considerable length.

The exhaust steam is condensed in a condenser having a cooling surface of 23,670 sq. ft. Recooled water is used for cooling. The condenser pumps can be driven either by a steam turbine or an electric motor. For greater economy the electric motor is run constantly.

The stuffing boxes of the high-pressure stage are connected with a small condenser which draws away the steam that would otherwise ooze out and condenses it.

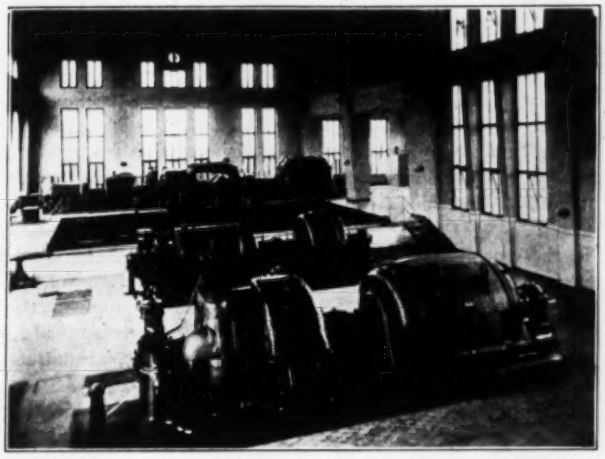


FIG. 15 VIEW OF TURBINE ROOM AND ITS THREE TURBINES, THE 18,000-KW. MACHINE BEING IN THE BACKGROUND

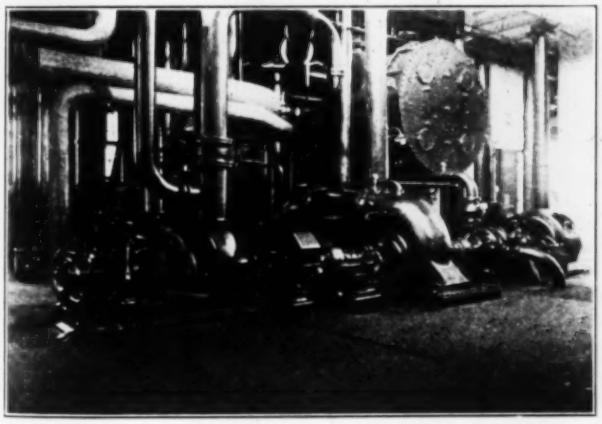


FIG. 16 CONDENSER LOCATED BENEATH THE 18,000-KW. TURBINE

The four housings of the turbine are split horizontally, and when the upper parts are lifted off, the shaft with the runner wheels becomes accessible. The housings of the first and second stage are made of cast steel; those of the third and fourth of cast iron. The blades of the high-pressure section are made of a heat-resisting nickel steel; the stuffing boxes and the labyrinth boxes are of monel metal. Each stage has a collar bearing.

The regulation of the turbine is effected by a governor located at the beginning of the third stage. The turbine has two-pressure regulation in order to enable it to work with steam of both 1700 lb. and 210 lb. pressure. At present it is so arranged that all the 1700-lb. steam is used as it is generated in the boiler, the governor supplying low-pressure steam as the load requires. Thus the regulation of the high-pressure part is influenced by the pressure in the boiler, and is so arranged that it automatically keeps the steam pressure in the high-pressure boiler at between 1500 and 1650 lb. per sq. in. Later, when the high-pressure boiler is fully completed, the relations will be reversed. There will be plenty of high-pressure steam and only a little low-pressure (210-lb.) steam which comes as waste power from the near-by cokery. The valve gear will then admit all of the low-pressure steam, maintaining the pressure constantly at this level as it did formerly with the high-pressure steam, and the high-pressure steam will be supplied in accordance with the load on the turbine.

The regulation of the turbine at part load is effected by pure

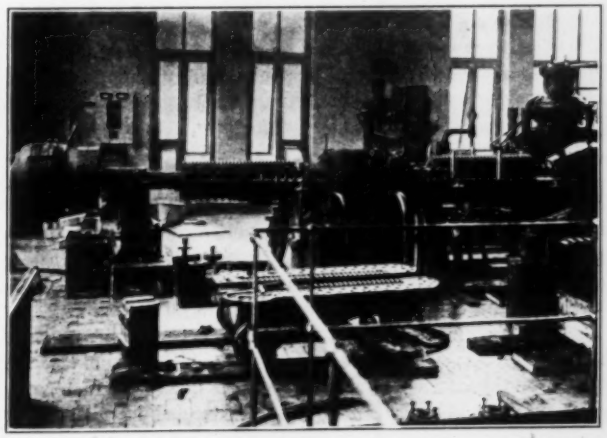


FIG. 17 SHOWING FIRST AND SECOND STAGES OF TURBINE OPEN, WITH WHEELS IN POSITION

FIG. 18 SHOWING THIRD AND FOURTH STAGES OF TURBINE OPEN, WITH WHEELS IN POSITION

throttling in the high-pressure valve gear; in the low-pressure valve gear it is effected by a combination of pure throttling and stage connection.

High-pressure steam is admitted through six valves which are arranged in three pairs opening one after another. Six valves are used in order to keep their dimensions within reasonable limits.

The admission valves are operated in the usual manner by servomotors actuated by oil under pressure.

Figs. 15–18 show views of the turbine room, turbines, and condenser.

Corresponding to the great quantity of steam and the diameter of the runner wheels in the high-pressure stage, which is from 11.8 to 12 in., the blades of the first wheel of the high-pressure stage

are 0.71 in. high. Thus the ratio between wheel diameter and blade length is quite normal, even in the first wheel of the high-pressure stage.

Operating Experience to Date

After beginning operation the suction of the feed pump of the high-pressure boiler had to be changed since the original diameter was too small. Further, the steam piping and the feed lines between the boiler, evaporator, and circulating and feed pumps had to be changed in position because they vibrated very strongly during the operation of these reciprocating machines. After these preliminaries had been attended to the plant began to be operated continuously on November 1, 1927, and up to the first of July, 1928, it had run for 3000 hours.

Outside of frequent changes of packing and tightening of the stuffing boxes of the circulation pump, no unusual maintenance operations have been necessary.

The flanges in the valves have kept permanently tight. The welds of the tubes, both those exposed to flame and away from it, have given no trouble. The tubes of the radiant-heat superheater and of the resuperheater are in perfectly normal condition both inside and out. They are particularly clean on the inside, without any scale deposits. A spongy sludge forms in the evaporator, but this can be removed by merely flushing with water.

The desired superheating temperatures have always been easily attained, even when the ducts of the boilers were not cleaned for two months, which in view of the poor quality of fuel—containing as much as 25 per cent ash—is an extended period of operation.

The burners in the combustion chamber are in good condition.

The tubes of the radiant-heat superheater become coated with a porous layer of ash after two or three days' operation, which drops off of itself when its thickness increases. This coating is no thicker after two months' operation than it is after only two days. On the upper third of the walls of the combustion chamber and near the burners the adhering slag melts and flows downward, glazing the walls. Lower down it solidifies and forms incrustations which are partly stalactitic and partly sponge-like; these either drop off themselves or are removed eventually by cleaning. The slag does not attack the firebrick walls of the combustion chamber. On the bottom of the chamber a solid granulated ash of close, fine texture is formed which is removed every other day. These favorable conditions obtain in spite of the high temperature of the combustion gas and the high percentage of carbon dioxide, both of which raise the temperature of combustion. The results are all attained through the enormous heat absorption by the radiant-heat superheater, which lowers the temperature in the combustion chamber to the desired predetermined one of about 2200 deg. fahr. slightly below the burners.

In the high-pressure section of the turbine no change has been observed in the runner wheels or blades which can be charged to temperature or flow of steam.

In the turbine blades and in the valve gear, deposits of sodium chloride have been found, which, it would seem, are due to the fact that the condenser is cooled with water drawn from a river into which the drainage of neighboring coal mines is discharged, and which in consequence is very salty.

Some of the brass cooling tubes built in the turbine condenser are not of the best quality, and therefore crack or lose their tightness. These defects can be attended to only on the nearest following Sunday, when the turbine is stopped. In the meantime cooling water which contains more or less salt is supplied to the turbine and thence to the boilers. The evaporators are washed out every eight hours, and yet with defects in the condenser a certain salt concentration gets into the evaporator. From determinations it appears that the sodium chloride of the solution in the evaporator is sublimated with the water at a temperature of about 612 deg. fahr. The steam is superheated in the superheater of the boiler, and thus sublimation is further promoted, consequently no salt deposits occur there. On the other hand, they appear where the condition of the steam changes through throttling or output of power. Salt deposits have been found in greater or less quantities at the reducing valves of the valve gear, in the wheels and blades of the first stage of the turbine, and also wherever leaks appear on the flanges.

This phenomenon is unusually important in high-pressure operation. It must be studied also in other places in order that remedies may be devised on the basis of our observations. In our case, a radical treatment of the condenser defects would easily do away with these troubles, for then no salt could get into the circulation. No corrosion or changes in the boiler pipes or in the runner wheels, guide wheels, and blades of the turbine were detected.

In the first stage of our work the effects of high temperature and high pressure on the materials of the boiler and the turbine were tested. Fortunately all calculations and assumptions were verified.

In the second stage, the economic advantages will be determined. On the basis of the efficiency determinations of the boiler and turbine, in so far as they have been possible with the small quantity of high-pressure steam used, we are justified in hoping that the economy as determined from original calculations will be fully attained.

In the fully completed plant there will be one 18,000-kw. turbine, one boiler capable of generating 39,600 lb. of steam per hour, and two boilers generating 88,000 and 110,000 lb. of steam per hour, respectively. Of these, one small and one large or two large boilers will be in operation. The third one will be held in reserve. With this arrangement it will be possible to operate entirely with high-pressure steam. The two new large boilers should be in operation by the end of 1929.

Use of High-Pressure Steam in Europe in Economic Power Generation

(*Continued from page 266*)

Great advantages can be attained with high-pressure operation, especially in the case of marine engines and locomotives. The German State Railway Company early recognized the importance of high pressures, and has ordered a number of locomotives of various systems. Among these is a 2000-hp. express locomotive provided with a Löffler boiler which will operate non-condensing at 1560 lb. and 932 deg. fahr. It is expected that this locomotive will have a fuel and water economy of about 50 per cent as compared with that of the best low-pressure locomotives extant, without higher cost.

Shipbuilders are exhibiting great interest in high-pressure steam operation. The insistent demand for higher speeds can only be met by a considerable increase in the powering of their vessels, and this can be obtained in an economical way only by employing high steam pressures; with these and also powdered-coal firing the operating cost will be only a third of what it is with Diesel engines. Even firing the boilers with fuel oil will effect a large saving.

The future of large-scale operation in electric power plants as well as in transportation—especially where in addition to electric current, heating steam is used—lies first of all in the use of high-pressure steam, which, when using the new boiler systems that insure positive control and absolutely safe steam generation, make possible large savings in fuel and in investment cost.

Research in Germany[1]

The Machinery for Conducting Research in Germany—Tendency Toward Americanization in Industrial Research—Projects of Scientific and Technical Committees of the V.D.I. Either Completed, Under Way, or Authorized

By J. M. SPITZGLASS,[2] CHICAGO, ILL.

RESEARCH in Germany, the same as research in the United States, is widely distributed over the industrial centers of the country. It is carried on by government institutions, state universities, technical societies, and by various commercial organizations. As in the United States, the research activities of the country divide the field into certain groups which may be classified arbitrarily, for the sake of comparison, into the following:

First, society or public research, which is done by individuals or groups of individuals for the advancement of science or industry in general. This class may also be termed cooperative research, since it involves the cooperation of various members for the interest of the society or the profession in general. As a rule both the method of procedure and the results obtained in this class of research are made available to the profession by proper publication from time to time.

Second, individual or private research. This class differs from the other in that its publications are governed by private interests. As a rule such research results in patent applications and in trade secrets of individual concerns.

As a general comparison it may be said that society research is more open and more cooperative in Germany than in the United States, while individual or private research in the industrial field is somewhat more secret and more individual than it generally is in our own country.

One cannot describe private research in any country—he can merely state the general tendencies and peculiarities of industrial developments. I am giving my personal observations, and my aim is not to criticize the activities of either country, but to bring out some of the points that it may be of interest to discuss and to compare with one another.

In the case of society research, the publications which record it are available to any one who cares to read them. Inasmuch as the German engineers are extensive readers and more than half of them are acquainted with English and French engineering literature, they are very well informed on foreign research. The reading of foreign literature is not common among American engineers, and it may therefore be worth while to acquaint the members of the Society with various research activities in Germany, which are listed on later pages with a knowledge and consideration of parallel activities in the United States.

Americanization Tendencies and Industrial Research

In visiting Europe one is much impressed with the interest shown by the German people in American developments in commerce, industry, and organization. One feels, with a sense of national pride, that Germany has discovered America as a source of organized activities and encouragement for large-scale developments. This attitude has a singular effect upon both the general life and the general industrial research of the German nation. In general life the visiting American is both envied and admired. He is envied in that as an American he must have considerable means. He is further envied in that as an American he has the privilege of entering the blessed United States at any time he wishes. The general saying is that the United States of America is the best country to live in and the worst country to get into.

The German's admiration for American industry is even greater than his envy of the American. The general public, which usually acts by instinct, prefers American goods to any other make. American automobiles predominate on the streets. American fruits, canned goods, notions, and even medicines are recommended as the best. I have discussed this attitude with well-informed people in Germany, and some of them thought that it was only a popular tendency which is strongly opposed by the patriotic tendency to foster German manufacture. After months of careful observation I came to the conclusion that the tendency toward Americanization is quite universal in Germany. The popular tendency is to prefer American goods, irrespective of who makes them or where they are manufactured. The patriotic or national tendency is for the Americanization of industry so that similar goods can be produced under the same conditions in Germany. In both cases Americanization is the chief motive: to buy American goods on the one hand and to manufacture the same kind and grade of goods in Germany on the other. This tendency has its effect not only upon the popular mind but also upon many national developments, and especially upon research activities in the industrial field.

To prove that the tendency toward Americanization in Germany is more than popular, I shall cite an interesting publication by the Verein Deutscher Ingenieure entitled "Das Wirtschaftliche Amerika" (Economic America), by Dr. Carl Koettgen, active chairman of the State Trustees for Economics. Dr. Koettgen starts his preface with the following statement:

> The United States of America brought the World War to an end. Through the Dawes Plan the United States stopped the destructive tendencies in the economic world. The United States is the first power in the world.
>
> Every way in Germany a comparison is drawn with similar relations in the United States—with economic America, her high wages, and her advance in machinery.

These are the two main points in the make-up of American prosperity that interest Germany—high wages and the increasing use as well as the increased development of machinery. Hundreds, perhaps thousands, of German students have visited the United States in order to study American methods of industrial development. Every one of them has been impressed with the advances in machinery, factory system, and mass production. They have also noted the high wages, but have attributed them to the higher standard of living in America. It did not occur to many that the high wages and the standard of living are very closely related to the advance in machinery and mass production. After all it is mass consumption that makes mass production possible, as it is the demand that eventually controls the supply. Increased consumption is a direct function of increased wages and a higher standard of living. Increased wages have some effect on increasing the cost of manufactured articles, but the possibilities of mass production offset that effect and make it possible to produce the articles at a reasonable price in spite of higher wages.

[1] Prepared for the A.S.M.E. Main Research Committee.

[2] Vice-President and Consulting Engineer, Republic Flow Meters Company. Mem. A.S.M.E.

The period of rationalization or reconstruction in Germany began with extensive developments in the steel industry along the lines of mass production and factory system, but these have not been very successful. Some believe the reason to be the difference in the make-up of the German laborer, who by nature is a mechanic rather than a factory hand. The fact of the matter is that factory systems were established and mass production was accomplished, but the articles produced in large quantities did not find the expected market. It did not occur to the Germans that the higher wages and the higher standard of living in the United States were responsible for the high consumption of commodities which justified the mass production and factory methods.

I am citing this instance only as a matter of comparison between the general research activities of the two countries. The standard of living and the wage question will affect the results obtained from industrial research. The lower wages and the corresponding lower standard of living may diminish the benefits that should accrue from research. On the other hand, the lower standard enables the accomplishment of research work at a corresponding lower cost, so that on the whole the research activities in German industry may and appear to be carried on with the same zeal and care as in the United States.

There are other points of interest in the make-up of German industrial research. To the foreign observer it seems peculiar that on one hand there are so many standing and current industrial exhibits throughout the country, and on the other that there is a general feeling in the trade that information should not be volunteered, that trade secrets are trade secrets and should be kept from the general public. One visiting a manufacturing establishment, when he is allowed to do so, has the feeling that he is treading upon sacred soil.

I am pleased to say that my personal experience has been entirely different in this respect. I have visited several concerns in Germany, including some of our closest competitors, and I was shown many details of the plant and of the manufacturing procedure. The general practice, however, is to avoid giving any more information than is absolutely necessary. As a typical case I may cite the circular, announcing the Sixty-Seventh Annual Convention of the Verein Deutscher Ingenieure. After the general program a list was given of fifteen groups of scheduled inspection visits in and around the city of Essen, where the convention took place. The first sentence of the introduction preceding the list read: "Members of competitive firms are asked to avoid taking part in the inspection visits to respective competitors." I might add, however, that no one ever inquired whether the prospective visitor was a competitor or not, but the feeling is that a competitor should keep away, even at the time of a so-called public demonstration.

Industrial expositions are fostered by the state and by municipalities throughout Germany. Each of the larger cities has exhibition grounds owned and controlled by the city. The city of Leipzig owes its growth and prosperity to the Leipzig Fair, which attracts the attention of the entire world. The outstanding features of an exposition in Germany are that the exhibition halls are built for the purpose of advancing a particular branch of industry, and every machine or device exhibited is in continuous operation during the hours the exhibition is open. Contrary to the practice in this country, an exhibit shows mainly what has been accomplished and not necessarily how it was accomplished.

SOCIETY OF PUBLIC RESEARCH

The outstanding feature of this group of research in Germany is the correlation of its activities through the main engineering society, the Verein Deutscher Ingenieure, in Berlin. This society subsidizes and controls practically all the research activities of the engineering profession. The experimental work undertaken by state, government, and scientific institutions is cleared through this engineering society, which represents the engineering profession of the German Republic. There are several other engineering societies, but these are more or less specific, each covering a single branch and being in the nature of a local section, while the "Verein" covers the whole profession and includes both the industrial and scientific branches of engineering.

The advantages of such an arrangement are manifold. In the first place, it eliminates the possibility of duplication of effort in research work. In the second place, it lends to each item the strength and authority of the whole profession and of the whole country. By virtue of this combination it is quite possible that society research may be more effective in Germany than in the United States. Publication by the Verein carries with it sufficient authority for a widespread utilization of the results obtained by research. These national tendencies must be considered in comparing the methods of procedure in the organization of committees for society research.

The German society has two main groups of committees, one being its Scientific Committees and the other its Technical and Professional Committees. The society has a standing Scientific Advisory Board which is similar to our Main Research Committee, but its scope is limited to work in the general field of engineering science. The group of Scientific Committees is supervised by this Advisory Board, which appoints the individual committees for the purpose of carrying out certain scientific developments of a fundamental technical nature. The group of Technical and Professional Committees is governed by the Managing Board of the society. Each Technical Committee is appointed by that board to cover a limited field of technical development, and each Professional Committee for the purpose of establishing rated capacities and acceptance tests.

The appointment of a committee by the society means the opening of a new branch for cooperative or society research on a given new subject. I observed the procedure in the formation of the German Committee on Flow Measurement, in which I took an active part as the representative of the Fluid Meters Committee of the A.S.M.E. After an understanding was reached between the headquarters of the two societies, the Managing Board of the German society addressed a letter, on May 1, 1928, to a number of its members (about twenty-five) informing them that the society had found it necessary to form a committee on the subject of flow measurement. These members were invited to the first organization meeting, which was to be held in Hanover, about six weeks later, around the middle of June. Because of my illness at that time the board was kind enough to shift the meeting date to July 6, and to hold it in Munich in order that it might be possible for me to attend. Notwithstanding that the shift was made on very short notice, every one who was invited came to the meeting in person. His attendance at meetings and interest in society work are another credit to the German engineer.

The procedure in the formation of this committee might have been somewhat different due to the fact that it involved an arrangement for cooperative work with our own society. However, there was no mention of this cooperation in the letter of invitation. A second letter was sent out on June 28, giving the following tentative program for the meeting in Munich on July 6, 1928:

ORDER OF THE DAY

1 Election of Chairman.
2 Address by Mr. J. M. Spitzglass on the work of the Committee

on Fluid Meters of The American Society of Mechanical Engineers.

3 Field of Committee Work:
Measurement of Flowing Gases, Steam, and Viscous Fluids by Means of Orifices, Nozzles, and Flow Meters.

4 Primary Work of the Committee and Apportionment of Same to Sub-committees:
a Definitions: Conceptions, nomenclature, basic equations, standard condition of gas (standard cubic meter).
b Collection and arrangement of experimental material available. Election of sub-committees for (*a*) and (*b*).
c New experiments (statement by engineer Stach, Bochum). Conditions for granting funds for experimental work.

5 Miscellaneous.

This tentative program shows that during this interval of time the management of the society, that is, the members of the staff in charge of the Technical Committees, had gone into the details and had taken the matter up with some of the members invited to the organization meeting. Under 4(*c*), new experiments, there was a mention of conditions for granting funds for experimental work.

Mr. Stach, who reported on that subject, recommended that the experiments be conducted in Göttingen, and asked the support of the committee in collecting funds for that purpose. He stated that the mining industry had already made an appropriation for this purpose, which he hoped would be continued if the investigations were made at Göttingen.

It appears that in the matter of subsidizing experimental work there is no noticeable difference in German practice from our own methods, with possibly one exception. In Germany the funds collected or provided by the society are granted not to a given committee but to the individual who is responsible for conducting the given experimental work. In the publications of the society where reference is made to research, the various reports are listed not as the work of given committees but of individual experimenters, whether or not they are subsidized by the society.

Research Projects Completed, Under Way, or Authorized

In the yearly report of society activities, published in the *Zeitschrift des Vereines deutscher Ingenieure* on May 26, 1928, the research activities on hand at the beginning of 1928 are divided into three classes:

1 Twenty-six reports completed in 1927
2 Thirty-four uncompleted experiments
3 Seventeen new projects.

In the listing of the new projects the amount of the money granted and the estimated time for completion is given for each item. For the convenience of our readers all the activities are listed below with reference to the standing committees of the society.

Scientific Committees

1 Committee on Heat Research: Chairman, Mr. Jakob
2 Committee on Vibrations: Chairman, Mr. Hort
3 Committee on Tables of Methematical Functions: Chairman, Mr. v. Mises

Technical Committees

1 Committee on Welding: Chairman, Mr. Fuechsel
2 Committee on Surface Coating and Painting: Chairman, Mr. Ellerbeck
3 Committee on Forging: Acting Chairman, Mr. Seidler.
4 Committee on Dust Technique: Chairman, Mr. Barkow
5 Committee on Hydraulics: Chairman, Mr. Galland
6 Committee on Steam Boilers: Chairman, Mr. Eberle
7 Committee on Materials: Chairman, Mr. Kühnel
8 Committee on Machine Operation: Chairman, Mr. Kronenberg
9 Committee on Textile Technique: Information
10 Committee on Flow Measurements: Chairman, Mr. Josse.

Professional Committees

1 Committee on Ventilators and Compressors: Chairman, Mr. Stach
2 Committee on Steam Power Plants: Chairman, Mr. Dörfel
3 Committee on Steam Turbines: Chairman, Mr. Josse
4 Committee on Gas Engines and Gas Producers: Chairman, Mr. Nagel
5 Committee on Water Motors: Chairman, Mr. Galland
6 Committee on Centrifugal Pumps: Chairman, Mr. Pfleiderer
7 Committee on Cooling Towers: Chairman, Mr. Huebscher
8 Committee on Heat Insulation: Chairman, Mr. Hencky.

The following outline will give at a glance the accumulation and progress of research work subsidized by and conducted under the auspices of the Verein Deutscher Ingenieure. It shows the research activities, through committee work and otherwise, segregated under the various committees or the corresponding subjects; also the progress of the work at the beginning of 1928, and the amount of money granted by the Society for each new project.

Projects of the Scientific Committees

1 Committee on Heat Research:

	Chairman, Mr. Jakob	Status
1	Henning, Charlottenburg: "Selective Gas Radiation"	In progress
2	Jakob, Charlottenburg: "Heat of Vaporization from 10 Atmospheres up"	In progress
3	Jakob, Charlottenburg: "Heat Conductivity in Metals at High Temperatures"	In progress
4	Jakob, Charlottenburg: "Condensation of Superheated and Saturated Steam"	In progress
5	Knoblauch, Munich: "Heat Transmission from Flowing Hot Air to Pipes and Pipe Groups"	In progress
6	Knoblauch, Munich: "Specific Heat of Steam at Pressures up to 120 Atmospheres"	New project, grant, R.M. 4000, 1 yr.
7	Knoblauch, Munich: "Effect of Heat Transmission on Temperature Measurements"	New project, grant, R.M. 1000, 6 mos.
8	Knoblauch, Munich: "Thermal Properties of Liquid Mixtures"	New project, grant, R.M. 3000, 1 yr.
9	Nusselt, Munich: "Transfer of Heat from Horizontal Steam Pipes to Still Cold Water	New project, grant, R.M. 1200, 8 mos.
10	Schmidt, Danzig: "Total Radiation from Carbon Dioxide"	In progress
11	Schmidt, Danzig: "Total Radiation from Steam at High Temperatures"	New project, grant, R.M. 1000, 6 mos.
12	Schmidt, Danzig: "Heat Transfer from Tubes to Viscous Liquids".	New project grant, R.M. 2000, 1 yr.
13	Trautz, Heidelberg: "Specific Heat of Gases at Constant Volume"	In progress

2 Committee on Vibrations:

Chairman, Mr. Hort

1	Esau, Jena: "Measurement of Damping Longitudinal Oscillations in materials"	New project, grant, R.M. 5000, 1 yr.
2	Esau, Jena: "Measurement of Damping Effects in Materials Used for Machine Construction"	Completed
3	Föppl, Braunschweig: "Damping Capacities of Building Materials"	Completed
4	Knoblauch, Munich: "Sound Damping in Passages	New project grant, R.M. 5000

5	Memmler, Berlin: "Determination of Strength Coefficients of Vibrating Bodies"	In progress
6	Prize Competition: "Critical Analysis of Vibration Methods"	Completed
7	Wagner, Berlin: Experiments on Resonance in Wooden Slabs for the Purpose of Determining Room Acoustics"	In progress

3 Committee on Tabulated Mathematical Functions:

Chairman, Mr. v. Mises

1	Malkin, Berlin: "Outline of Bessel and Elliptic Functions"	Completed

PROJECTS OF THE TECHNICAL COMMITTEES

1 Committee on Welding:

Chairman, Mr. Fuechsel

		Status
1	Bardtke, Wittenberge: "Methods for Testing and Inspecting Welds"	Completed
2	Henning, Charlottenburg: "Temperature of the Acetylene Welding Flame"	Completed
3	Kantner, Wittenberge: "Conditions for the Covering of Welding Rods"	Completed
4	Kantner, Wittenberge: "X-Ray Work in Welding Technique"	In progress
5	Neese, Ratingen: "Standards for Electric Welding Apparatus"	In progress
6	Rimarski, Berlin: "Tests of the Purity of Gases Used for Gas Welding"	Completed
7	Strelow, Hamburg: "Photographing the Electric Welding Arc"	Completed

2 Committee on Surface Coating and Painting:

Chairman, Mr. Ellerbeck

1	Nettmann, Charlottenburg: "Atomizers for Use in Mechanical Painting"	In progress
2	Nettmann, Charlottenburg: "Effect of Suction on Paint and Atomizers"	In progress

3 Committee on Forging:

Acting Chairman, Mr. Seidler

1	Tafel, Breslau: "Determination of the Crushing Point and Power Required When Forging Different Metals at Different Temperatures"	In progress

4 Committee on Dust Technique:

Chairman, Mr. Barkow

1	Burchartz, Dahlem: "Determination of Grain Size of Small Particles"	Completed

5 Committee on Hydraulics:

Chairman, Mr. Galland

1	Flügel, Danzig: "Flow of Fluids in Pipe Bends"	Completed
2	Jakob, Charlottenburg: "Measurements of Large Volumes of Gas"	Completed
3	Kehrmann, Koln: "Flow Conditions at Pump Valves"	In progress
4	Loschge, Munich: "Dependence of Discharge Coefficient on Nozzle Form in Steam Measurement"	New project, grant, R.M. 3000, 1 yr.
5	Schmidt, Danzig: "Behavior of Nozzles and Orifice Diaphragms in the Measurement of Viscous Fluids"	New project, grant, R.M. 1200, 8 mos.
6	Wagenbach, Darmstadt: "Accurate Water Measurements with Screen to Determine Value of Overflow	New project, grant, R.M. 500

6 Committee on Steam Boilers:

Chairman, Mr. Eberle

1	Bach-Baumann, Stuttgart: "Stresses in Boiler Plates Around the Manhole"	In progress
2	Berl and Staudinger: "Influence of Alkali Content of Feedwater on Boiler Material and Operation"	New project, grant, R.M. 1000
3	Knoblauch, Munich: "Water Circulation in Steam Boilers"	Completed, grant, R.M. 500
4	Raisch, Munich: "Heat Conduction and Disintegration of Fire-Brick at Temperatures Exceeding 500 Deg. Cent."	Completed
5	Schlesinger, Charlottenburg: "Combustion in Steam Boiler Furnaces"	In progress

7 Committee on Materials:

Chairman, Mr. Kuehnel

1	Baumann, Stuttgart: "Systematic Research on Lock Nuts"	In progress
2	Graf, Stuttgart: "Experiments on the Strength of Wooden Supports"	In progress
3	Graf, Stuttgart: "Fire Protection for New Wooden Structures"	In progress
4	v. Möllendorf, Berlin: "Fireproof Qualities of Various Materials"	In progress
5	v. Möllendorf, Berlin: "Properties of Wood and Similar Substances"	In progress
6	Nádái, Göttingen: "Tests on Elasticity"	Completed
7	Rotscher, Aachen: "Strength of Crossheads"	Completed
8	Rotscher, Aachen: "Distribution of Stresses on Shrunk Shafts"	New project, grant, R.M. 1000, 6 mos.
9	Rotscher, Aachen: "Strength of Conical Pistons"	Completed
10	Schlesinger, Charlottenburg: "Torsion and Shearing Tests"	Completed
11	Seidl, Berlin: "Crushing and Breaking Tests on Various Stones"	In progress
12	Siemann, Bremen: "Elongation Measurements in Hulls of Ships"	In progress
13	Strelow, Hamburg: "Strength Tests of Welded and Riveted Beams"	Completed
14	Wörnle, Danzig: "Systematic Tests on Wire Cables"	In progress

8 Committee on Machine Operation:

Chairman, Mr. Kronenberg

1	Gottwein, Breslau: "Effect of Cooling and Lubricating on Surfaces Being Machined"	In progress
2	v. Karman, Aachen: "Relief Tests on Rotating Machines"	In progress
3	Nusselt, Munich: "Knocking in Gas Engines"	New project, grant, R.M. 2400, 1 yr.
4	Sachsenberg, Dresden: "Tests on Reamers"	Completed

9 Committee on Textile Technique:

In formation

1	v. Möllendorf, Berlin: "Properties of Textiles"	In progress

10 Committee on Flow Measurements:

Chairman, Mr. Josse

This committee has recently been appointed to collaborate with the Fluid Meters Committee of The American Society of Mechanical Engineers. Previously matters dealing with fluid flow were referred to the German Hydraulic Committee.

11 Aeronautics

1	Betz, Göttingen: "Wind-Pressure Measurements on Models".....	Completed

12 Lubrication

1	Frank, Berlin: "Aging of Lubricating Oils".....	Completed
2	Frank, Berlin: "Evaluation of Lubricating Oils".....	Completed
3	Hilliger, Berlin: "Oil Tests".....	Completed

13 Miscellaneous

1	Flügel, Danzig: "Mixing Phenomena in Jets".....	Completed
2	Knoblauch, Munich: "Checking of Thomas' Model Tests".....	New project, grant, R.M. 1000, 6 mos.
3	Wallichs-Schöpke, Aachen: "Construction of a Special Support for Measuring Instruments".....	In progress
4	Zäpke, Berlin: "Test Methods for Solid Fuels".....	New project, grant, R.M. 700, 6 mos.

Only one report of the Professional Committees for capacity and acceptance tests was published in 1927, namely, that of Mr. Pfleiderer of Braunschweig, under the title of "Tests On Centrifugal Pumps and Compressors." This report refers to the work of the Committee on Ventilators and Compressors under the chairmanship of Mr. Stach.

From the yearly financial report of the society it appears that M.116,000, or about $28,000, was spent on scientific work, committees, and research. For 1928 the budget allowed M. 206,000, or about $50,000. The seventeen new items listed make a total of M.53,000, or about $13,500, allowed to individuals for expenditures necessary to carry out the experiments. I assume, therefore, that most of the $50,000 allowed for 1928 will be spent in a similar way in order to cover all the items of research activities of the society.

It is the usual practice in Germany to hold technical meetings during holiday seasons, Saturdays and Sundays included. A meeting is called specifically for a given committee, and naturally only those who are interested in the subject of that committee will attend. While the attendance at each particular meeting is not very large, the discussions are lively because of the interest of the members present.

To summarize my personal impressions of research in Germany, I have observed with interest the tendency toward Americanization in the field of research, but that tendency does not convey the same impression that the old label "Made in Germany" used to in the United States. It is a tendency toward obtaining similar results, but not necessarily by identical means. Therefore it behooves us to make a closer study of the methods employed for cooperating the groups of society research in Germany, to see whether such methods could not be applied equally well in certain cases of society research in the States.

Military Transportation

THE following is a verbatim abstract of parts of the address by Major General Hanson E. Ely, U. S. A., dealing with the railways in time of war.

"We have had the experience of the great World War where transportation was used more than in any other we have ever had. Since the end of that war our railway transportation has been tremendously improving. Some $6,000,000,000 have been expended on terminals and roads and replacements of equipment and such things as that.

"The statement, as I remember, of the Secretary of War, at the time the Government finally took over the railways, was that there were 150 ships in the New York harbor waiting for coal; there were 30,000 cars around in the Jersey meadows and near by, waiting to get to the ships, and 300,000 tons of coal waiting to be transported a few miles to shipboard, and none of them able to move.

"Congestion east of Pittsburgh and north of the Potomac was so great that transportation was very much tied up. I know how it was in France, and General Atterbury knows better than I. Everything was rushed to terminals and the docks. The great mistake was made of making contracts with interior factories and agreeing that they would be paid on delivery in New York City—and so they grabbed all the cars they could and rushed everything into New York City. The material couldn't be sorted and they had to send a great quantity of material that they didn't need in France to be sorted over there—and they were pretty well congested over there.

"We can't afford to risk a repetition of such a condition. The idea now of the use of railways in a future war is that under the general direction of the Secretary of War, acting for the President, the American Railway Association will practically run all the railways. It will have its representative in Washington and at each of the ports of embarkation, and at the terminals and at various places where they are most needed, paralleled by the military who will give them no technical instructions. They will be operated as railroads in the most scientific manner, and all the military will do will be to give them the military priorities, the military requirements, leaving to them the execution of those policies—a general staff control, you might say; the railroads operating as they now operate, but controlled by the American Railway Association, whose control will be much more absolute.

"I believe personally from a study that it was a mistake, that we didn't need to take over the railways. It is a principle not only with railways but with everything else technically operated that the men that are on the job and know the technical methods of working most efficiently must be left there. They can operate it with the greatest efficiency, but there will be power and supervision above them so that if by chance in a large body of men there will be found those trying to do this or that and who don't play the game, they will be eliminated. It is the same in the military. If your division commander or regimental or brigade commander didn't play the game, he was brushed to one side and never given another chance. You can never give a man two chances in war; it is too important.

"However, in war time judgments are not so clear and sometimes are not taken with very great consideration. While this method should be efficient, there is always the chance that some things which occurred in the World War may occur again. The President of the United States in war time is charged with the safety of the nation, put there by the votes of the people of the United States—he has his agencies for carrying on a war and he must use them, and the responsibility is his of using those agencies most efficiently; whether it be commanders in the field or railway men or factory owners and producers makes no difference. War is a hard master, and the individual must be submerged in the necessity of the nation." (*Proceedings of the Fifth Annual Meeting of the Atlantic States Shippers' Advisory Board*, New York, Jan. 18, 1929, pp. 40–41, *g*)

Second Robert Henry Thurston Lecture on the Relation Between Engineering and Science

The Mechanical Properties of Materials as Shown by Studies on Single Crystals

Explanations of the Elastic After-Effect, the Elastic Limit, the Mechanism of Plastic Deformation, and the Strength of Materials, Based on the Results of Joffé's Experimental Work

By WHEELER P. DAVEY,[1] STATE COLLEGE, PA.

W. P. DAVEY

A YEAR ago a brief summary was given before this Society of certain X-ray studies on metals and their alloys. Those studies dealt chiefly with the differences in ductility which are inherent in various crystal structures, with the increase in strength due to alloying, and with some of the theory of what goes on in carbon steel during heat treatment. Last year's paper dealt largely with work with which the lecturer had been intimately associated. Having been asked that the results of still other X-ray studies be presented at this time, it seems only proper to direct attention to the work of others on the properties of crystals. The present discussion will center about the brilliant work of A. Joffé and his co-workers on the explanation of the elastic after-effect, the elastic limit, the mechanism of plastic deformation, and the strength of materials.[2]

Elastic After-Effect

It is well known to all mechanical engineers that if a stress is applied to any ordinary solid body a strain is produced which increases with time, so that the final deformation is approached asymptotically. Similarly, when the stress is removed the body returns asymptotically to its original state. This results in an elastic hysteresis (elastic fatigue) in vibrating bodies. Ordinary structural materials are hardly suited to experiments on the cause of this phenomenon, and Joffé was led to try single crystals of quartz.

Deformation of quartz rods was measured by an interferometer method using monochromatic sodium light. A deformation of 1000 fringes showed what looked at first to be an elastic after-effect, for the deflection crept slowly up to 1009 fringes. It was calculated that thermal effects would account for a change in deflection of 2.1 fringes within 0.07 sec. after the load was applied. This is obviously included in the original reflection of 1000 fringes. Electrical phenomena, which are present in quartz but which are absent in metals, were shown to cause a slow creep of 9 fringes. When these electrical effects were removed by repeated exposure of the quartz to radium, no creep in the deflection could be measured. For a total deformation of 3000 fringes (measured 1 sec. after the load was put on) the total creep in 24 hours was not more than 0.1 fringe. This means that if there is any elastic after-effect it must be less than three hundred-thousandths of the initial deformation. This is only one-thousandth of the elastic after-effect usually found in structural materials.

Subsequent experiments showed no elastic after-effect in single crystals of W, Zn, Cu, and Bi as long as the elastic limit was not exceeded. We may therefore feel safe in making, with Joffé, the general statement that there is no elastic after-effect, elastic fatigue, etc., in single, pure, homogeneous crystals. These effects are due to "the irregularities of heterogeneous bodies, to deformations beyond the elastic limit and rupture inside small weak spaces within the body, and to interactions between the crystal grains."

Elastic Limit and Plastic Deformation

The elastic limit is ordinarily defined as the limit beyond which Hooke's law no longer holds. In terms of the usual engineering tests the elastic limit is indicated by a permanent deformation. More accurate measurements show, however, that the ratio of stress to strain is not a constant even before the point of permanent deformation. Calculations based on the electrostatic theory of crystal lattices show that instead of the stress f being simply proportional to the strain Δr (i.e., $f = f' \Delta r$), it is to be represented by an infinite convergent series of the form

$$f = f_0 + f' \Delta r + \frac{1}{2!} f'' (\Delta r)^2 + \frac{1}{3!} f''' (\Delta r)^3 + \ldots .$$

Normally f_0 is zero, so that Hooke's law is to be regarded as only an approximation based on the neglect of terms of higher order than $f' \Delta r$. It is therefore to be expected that Hooke's law will fail for very refined measurements. The fact that it holds as well as it does up to the point of permanent deformation led Joffé to investigate the mechanism by which a permanent set is produced.

A permanent deformation in a single crystal might be caused merely by portions of the crystal sliding over other portions in the same way that playing cards do when the pack is bent, or it might be a combination of this effect with a second effect, namely, the break-up of the crystal into small, closely adhering fragments which suffer a rotation while they are being formed. X-ray experiments soon satisfied Joffé that this destruction of the single crystal actually occurs during plastic flow. Plastic flow of solids, therefore, is characterized by the break-up of each single crystal into a group of smaller grains without affecting the actual continuity of the solid. An analysis of the forces involved shows that when the crystal breaks up, the fragments must become rotated about some axis. It is found experimentally that this axis of rotation may be either perpendicular to the slip planes or may lie in a slip plane. The common axis of rotation for all the crystal fragments leads to a fibering effect, for it requires all the fragments to have a common direction for some one plane. This rotation effect is identical with that found independently by metallurgists and physical chemists in this country and in Europe.

The gradual application of a stress on a single crystal produces no effect beyond that of a purely elastic deformation until the stress exceeds a critical value which is a characteristic of the material. As soon as the stress exceeds this critical amount, a

[1] Professor of Physical Chemistry, School of Chemistry and Physics, The Pennsylvania State College.

[2] In this connection see Joffé's very interesting book" The Physics of Crystals" (McGraw-Hill), which gives a fuller account of his work than can possibly be given here.

Delivered at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 3 to 7, 1928.

permanent deformation and a fragmentation of the single crystal occur simultaneously. It is this critical stress which is usually called the elastic limit. Because of its effect in breaking the crystal into fragments and in rotating those fragments, Joffé proposes to call it the "destruction limit."

That this limit is a definite quantity is shown by the fact that in a test accelerated by working at a temperature of 500 deg. cent. the X-rays show no destruction of a rock-salt crystal in 24 hours if the stress is 2 per cent below the critical value, but they show a measurable destruction in one second if the stress is 2 per cent above the critical value. This effectually disposes of the statement so frequently found that "all substances flow more or less slowly," and establishes on a firm foundation the existence of actual solids in the crystal state. By way of further confirmation it may be mentioned that the critical stress necessary to give the destruction limit is independent of the size of the crystal and of the ratio of the cross-section of the crystal to its length. As might be expected, the critical stress required for the destruction of a single crystal decreases as the temperature is increased, and reaches zero at the melting point.[3] Of course, the size of the stress which just produces destruction depends upon the orientation of the crystal with respect to the acting force.

If a heated single crystal of rock salt or of zinc is given a shear, the plastic deformation proceeds by a series of separate jumps which occur at what seem at first to be regular time intervals. For a given set of experimental conditions, the magnitude of the jumps remains constant throughout the experiment, but the time intervals between them increase gradually in a regular fashion until, after several thousand jumps, they become very infrequent and finally cease. Increasing the shearing load decreases the time interval between jumps. The magnitude of the individual jumps is greater the higher the temperature. It is true that the plastic flow of solids may be expressed (at least sufficiently well for technical purposes) by the same general type of equation as is used for the flow of viscous fluids, but the mechanism of the flow must be quite different in solids from what it is in liquids.

The increase in the length of the time intervals between jumps in the experiment described above corresponds to the strengthening of a metal by cold work. It is evident that any explanation of the effects of cold work must be such as to necessitate the intermittent type of flow which has just been described. This would seem to dispose of the theory that cold working produces rather smooth, regular curves in the layers of atoms in the crystal. Slip along such curves would not become increasingly difficult, nor would it proceed by regular jumps of more than a single atomic diameter. This leaves two theories to be considered. According to the first of these, the atomic layers along which slip takes place suffer distortion to give a sort of corrugated surface (possibly even a cross-corrugated surface). Such a roughening could not take place in a given atomic layer without producing a similar, but somewhat smaller, roughening on the next adjacent layer. The irregularity in structure would thus be greatest at the plane of slip and would become progressively less at greater distances from that plane. The changes in this picture which are necessary to make it fit the previous picture of crystal fragmentation at the elastic limit are obvious. It is evident that when a plane has become a slip plane, and as a result fragmentation has occurred in the immediate vicinity of this plane, further slip on that plane is more difficult and the elastic limit *at that plane* is raised. The midpoint between two such planes of slip is therefore the point of lowest elastic limit, and is the place where the next slip plane is most likely to be. This picture accounts, then, for the increase in strength with cold work, the regular distances between successive slip planes, and the step-by-step type of plastic flow.

The second theory really seems to point pretty much to the same sort of picture, but it uses the more exact language of crystal energetics. Slip is considered as a release of the elastic energy from a strip in the crystal so thin that it consists of only a few layers of atoms. Since the crystal is to be thought of as being fragmented at the slip planes, it is to be expected that compressional waves will be reflected by planes where slip has occurred because of the altered elastic constants in the neighborhood of these planes. This reflection serves to prevent the influx of energy from other portions of the crystal. If we once grant that slip may occur in a time which is short compared with the velocity of sound in the crystal as a whole, it follows that the energy for any given slip comes from a very thin layer. If the increment in total energy per unit volume caused by a unit stress is E, then the increment in potential energy is $^1/_2E$. The increase in energy U_1 caused by a stress p in a strip of crystal of surface S (measured parallel to the slip plane) and thickness D is then

$$U_1 = {}^1/_2 E \times SD \times p^2$$

If α is the energy per unit surface area of the slip plane which is required to barely cause slip, then an energy

$$U_2 = 2\alpha S$$

will be required to cause slip over a surface of S square centimeters. (The factor 2 is required by the fact that slip occurs on *both* sides of the slip plane.) The lowest stress p_0 which can produce slip is given by $U_1 = U_2$, so that

$$p_0 = 2\sqrt{\frac{\alpha}{E}} \times \sqrt{\frac{1}{D}}$$

As D becomes smaller by reason of successive slips, p_0 becomes larger, i.e., the elastic limit is raised by slip and will not fall below the new value unless the irregularities at the slip planes are destroyed by heating. Since the energy for each slip plane comes from a limited region, it is inherent in the picture we are employing that plastic deformation of a solid must be a step-by-step process.

TENSILE STRENGTH

Experiments have been made showing the variation of both the tensile strength and the elastic limit of rock salt with change of temperature. The elastic limit was measured in terms of the "destruction limit," i.e., the critical stress required to change a single crystal into the polycrystal state. It has already been shown that the elastic limit is zero at the melting point. As the temperature is lowered from the melting point, the elastic limit increases at a considerably faster rate than the tensile strength, so that at some sufficiently low temperature (200 deg. cent. for a single crystal of rock salt) the curves for elastic limit vs. temperature and for tensile strength vs. temperature cross. Above this temperature a mass of rock salt may be given a plastic deformation, and if the stress is high enough to produce rupture, the rupture is characteristic of a plastic body. Below this temperature a single crystal of rock salt breaks before it reaches its elastic limit; that is, it ruptures like a brittle substance. We may generalize the results of this experiment by saying that any body is brittle at a sufficiently low temperature and plastic at a sufficiently high temperature.

It would seem at first sight that if tensile-strength measurements are made of single crystals at sufficiently low temperatures,

[3] The accuracy of the experiment was such that any possible deviation from zero must have been less than 0.1 per cent of the destruction limit at room temperature.

we should obtain a value which might be compared with results calculated from the electrostatic theory of crystal lattices. It is perfectly possible to calculate what the tensile strength of a single crystal of NaCl should be, merely from a knowledge of its crystal structure, a knowledge of the size of the electric charges on the Na^+ and Cl^- ions, and a reasonable extension of the laws of electrostatics to very short distances. An adequate treatment of calculations of this sort requires so much space that it is necessary to refer to the literature[4] for the details and the possible mathematical short cuts. The end result of such calculations for NaCl shows that it should have a tensile strength of about 200 kg. per sq. mm., or about 275,000 lb. per sq. in. Actually the tensile strength of rock salt, measured in the ordinary way, is only about $^1/_{450}$ of this, or about 610 lb. per sq. in. Painstaking experiments show, however, that if the measurement is made while the salt is held in fresh hot water the measured strength rises to 160 kg. per sq. mm. or 220,000 lb. per sq. in. Evidently the action of the fresh water may be explained as being a method by which surface cracking is prevented. All that is necessary is to have the rate of solution greater than the rate of propagation of surface cracks. It is true that the rock salt is pulled beyond its elastic limit and therefore suffers slip and consequent "destruction" to the polycrystal state during the application of the stress. But it is equally true that no material can be stronger than the summation of the forces of cohesion which bind adjacent atoms together.

From this viewpoint the results quoted look very favorable, and we feel justified in assuming that, if surface cracking could have been entirely prevented, the experimental value of the tensile strength would have been equal to that which was calculated from the electrostatic theory of the crystal lattices.

These experiments by Joffé and his co-workers were made on the crystals of a compound. To those working on the properties of crystals it seems reasonable to suppose that similar results could be obtained with metals or their alloys. If this viewpoint is correct we, like Joffé, may generalize by saying that "the problems of the tensile strength of solids, the influence of the size and arrangement of crystalline grains, of cold working, and so on, presumably involve the process of growth of small crystalline crevices throughout the grains and on the boundaries of grains."

Conclusions

We have taken up in a brief way the theoretical pictures of fatigue, elastic limit, plastic deformation, and tensile strength. It is a fair question to ask what use can be made of these pictures. The answer is that if we can learn enough about the forces of nature and about the principles which underlie the properties of materials we can hope to predict the properties of hitherto untried materials; we can hope to systematically develop new materials with highly improved properties in specialized directions to meet new needs; we can hope that by adding these pictures to those which were given here a year ago, we can penetrate further into the possibilities which the world holds out for the use and comfort of mankind; in short, we can hope some day to develop this portion of our science to the point where it becomes engineering. When that end is attained we can then turn our attention to still other portions of our subject, knowing that the field of knowledge to be explored, even in one subject, is so large that we can never hope to reach the end.

[4] M. Born, "Atomtheorie des festen Zustands" (1923). J. J. Thomson, *Phil. Mag.*, vol. 43 (1922), p. 721. W. P. Davey, *General Electric Review*, vol. 29 (1926), p. 580.

Program of the Joint Research Committee on Welding of Pressure Vessels

THE American Bureau of Welding and The American Society of Mechanical Engineers have organized a Joint Research Committee on Welded Pressure Vessels to investigate in a comprehensive manner the strength of vessels and properties of joints of different types, with the expectation that the data obtained will assist the A.S.M.E. Boiler Code Committee when it revises its rules and regulations governing the construction of pressure vessels, and will also furnish useful data to designing engineers and tank manufacturers.

The present code for the construction of unfired pressure vessels by the Boiler Code Committee is considered unduly restrictive, in that the allowable fiber stress is only 5600 lb. and there are severe restrictions as to size of tanks, thickness of plates, and working pressures. If the present code is adopted by the various states it would cause considerable hardship to the tank manufacturers, and it is therefore to their interest to cooperate in the proposed program in order that these restrictions may be removed.

About four years ago a preliminary series of tests on pressure vessels were made at the Bureau of Standards, the results of which were helpful to the Boiler Code Committee. Unfortunately, they were not as comprehensive as desired since they did not include many forms of joints and pressures. The present investigation is to be comprehensive, and it has been accordingly suggested that studies of breathing tests of tanks and the effect of welding on the parent metal be included. Therefore, in order that this study be as complete as possible it is essential that the cooperation of the entire pressure-vessel industry be secured.

A program of investigations has been prepared by the Pressure Vessel Committee and approved by the Boiler Code Committee as capable of giving the type of information and data that the Boiler Code Committee would like to have in considering the modification of the present rules.

The testing work will be done at the Bureau of Standards. An investigation carried out on a cooperative basis will yield results of many times the value of the expenditure of any single company.

The manufacturers of welding apparatus and supplies are willing to contribute half of the necessary cash funds providing the tank manufacturers contribute the other half and supply the needed tanks. Several of the apparatus manufacturers will also supply tanks. Tank manufacturers are requested to furnish $300 for each three tanks submitted.

It is estimated that a total of about twenty-five thousand dollars in cash will be needed. The National Research Council will act as treasurer for the funds.

Additional cooperation is needed on the part of tank manufacturers to secure many of the types of tanks which are manufactured by various tank manufacturers. The Pressure Vessel Committee in its recommendations to the Boiler Code Committee must base their findings on the types of tanks tested.

Should manufacturers offer tanks of other forms and dimensions than those specified, their offers will be carefully considered by the Committee, and if a satisfactory agreement is reached the tanks will be tested along with the others.

All tank manufacturers desiring to cooperate in this program should communicate at once with the Secretary of the Pressure Vessel Committee, 29 West 39th Street, New York, N. Y.

Halving the Working Force and Stopping Production Leaks Through Simplified Production Control

By K. R. WOOD,[1] CHICAGO, ILL.

This paper gives details regarding the adaptation of an electromechanical dispatching device to the particular needs of a manufacturing concern, as well as the results obtained from its use.

WITH production on the increase and with the manufacturing departments distributed over a fairly widespread plant, some means were needed for bringing together to as great an extent as possible the control and operating departments of the company with which the author is connected. Some distance-annihilating device would serve, if such could be found.

It was found in the Temporator, an electromechanical dispatching device, which we adapted to our own particular needs. With it the workmen themselves signal job time changes and other information direct to a central control desk so that the status of every job is known at this central point at any instant during the day.

In this way it has been possible to eliminate several handlings of our shop "paper," to cut our force by one-half, to stop production leaks, and to avoid confusion.

The first step in our method of getting a simplified production control is in connection with the dispatching of time changes on jobs, for in order to arrive at operation costs there must of course be employed some method of timekeeping. Our practice is to dispatch notice of change from one job to another by the workmen direct to a central station where this change is recorded and the elapsed time is figured. This is accomplished by means of the Temporator, which operates by a dialing method much as does the automatic telephone.

In fact, the central station closely resembles a telephone switchboard in that it has its plugs, jacks, signal lamps, etc. But it is vastly different in one respect: the human voice does not enter into its operation. Moreover, herein lies much of its success, for its signals are easily translatable into valuable information even if sent in by a workman who can neither speak English nor write a readable hand.

The dials which the workmen use are the same as those employed in automatic telephones. And at the central station the indicating device is a step-by-step mechanism which reveals visually behind a tiny window a row of digits corresponding to the code number dialed by the workmen. Not only does the digit or letter dialed appear in front of the central-station operator, but also in a window at the top of the sending unit. Thus the person dialing has a check on what he is doing: he may be sure that all the figures are correct as he intended them. These dispatching units are placed in convenient positions about the departments wherever there are workmen who have occasion to report direct labor.

In connection with this, two main forms are employed: a Routing or Shop Order, and a Job Time Card.

The job time cards are printed both in red and in black, and are alternated daily. Thus one color of card carries Monday, Wednesday, and Friday, and the other, Tuesday, Thursday, and Saturday. When one set is in use at the central board, the next preceding day's cards are in the hands of the accounting department where a disposition is made of elapsed time against the cost card. This dispatching method makes possible the accumulation of the elapsed time on cost cards with but one handling between the workmen and the accounting department, which minimizes the chance of errors.

The routing or shop order is made out in quadruplicate from a preplanned work schedule. The four copies tie into the timekeeping system and assist in controlling production, opera-

FIG. 1 ROUTING ORDER AND JOB TIME CARD

tion costs, departmental performance, progress of work, and follow-up, and furnish other statistical information such as operation interference and performance studies.

Further, this shop order carries all the information necessary for directing the routing of tools and work to the department, the reporting of time change, the time allowed to perform the work, and the number of pieces to be made.

This particular form and its three carbon copies function in various ways and with a variety of persons, so that they make possible the systematic direction of the work and at the same time help all concerned to visualize quickly the part each plays.

The first copy is put into Kardex pockets at the central Temporator board and filed under the department heading. Since these Kardex "leaves" or boards are held vertically in a turntable mounting, they are readily accessible to the operator.

Similarly, the second copy goes in a series of Kardex pockets

[1] Production Manager, Bell & Howell Co.

Presented at the Annual Machine-Shop Practice Meeting of the Chicago Section of the A.S.M.E., Chicago, March 14, 1928.

at the foreman's desk. This, then, so far as that one department is concerned, is a duplicate of the file at the Temporator central board, and it allows the foremen to visualize quickly the work ahead of each workman or work station.

The third copy serves as a "traveler" and remains with the work itself as a means of identification; and it is this copy which is used by the workman to dial his time change.

The fourth or memorandum copy is sent directly to the tool-storage crib where it gives the necessary information so that the tools needed to perform the work may be turned over to the transfer clerk and by him dispatched to the job. It is then returned to the central station, where it is placed in a follow-up file against the starting time of the job.

FIG. 2 CENTRAL BOARD OF SYSTEM

FIG. 3 WORKMAN USING DIAL

It should be explained at this point that only the first two copies of the routing order bear the allowed time of the operation. Thus this information is in the hands of the planning department and the foreman only.

As the workman nears completion of a job upon which he is working, the foreman assigns him his next job. When the job in hand is finished the workman notifies the central office of all the facts by means of the Temporator: he steps to the nearest signaling station, presses a button, is assigned a line, and dials his department and check number, the operation number, manufacturing-order number, design number, the number of pieces completed, and the symbol for "job finished."

Twelve digits and symbols are available in the Temporator apparatus employed, so that this number may be dialed without clearing the line and starting a fresh series. In our case these twelve separate digits are arranged as follows: at the left comes first one letter, then five digits, then two letters, and finally four digits. This is sufficient to give all the necessary information relating to the completion of the job in hand.

After the foregoing information has been transcribed by the central operator, the line is cleared and the workman repeats the dialing with reference to the new job which is about to be started.

This time is change recorded and controlled at the central board in the following way: When the dialing commences, or at least when it has progressed far enough to reveal the order number, the central operator reaches for the job time card in the file and strikes it twice in the time clock—once for finished job, and once for new job—records the number of pieces completed, the work station, operation number, and manufacturing order of new job started.

FIG. 4 FILING POCKETS AND DIAL AT FOREMAN'S DESK

He then passes this card along to an assistant operator, who pulls out the routing order for both jobs and stamps them in the time clock. The assistant then refiles the new job order and turns over the order covering the finished job to the planning clerk, who uses it in bringing his preplanned graph up to date, recording the whereabouts of work in process.

When the planning clerk is through with it, the order is turned over to an assistant who figures the elapsed time against the number of pieces made and time allowed. If the time is bettered, this is recorded on a Labor Analysis Card to be used in the future as allowed time on this job when it is run again. If the allowed time is not made, the order is turned over with others to the production-department foreman. Should the performance be notably bad, the order is sent to the production manager's desk and the foreman is called in to explain.

When the assistant central-board operator replaces the order in the pocket, after stamping the time of start on a new job, she applies a red spot to it with a rubber stamp. This indicates that the order is in work. Daily she checks through accumulated fourth copies in her file against the date the work is scheduled to start. She does this by matching the order to the red spot, which makes it easy to visualize whether or not a job has started on time.

An interesting feature of the control concerns the watching of elapsed time. If the foreman is doubtful about any job, or thinks he is losing time on it, he is privileged to signal through the Temporator signaling station nearest his desk to the central board for a check-up figure. The central operator then dials back to him the total elapsed time on that job. This gives the foreman an opportunity to catch up or speed up on his work before it is too late.

Under this plan of production control we no longer require checkers for the purpose of gathering up the evidence and piecing it together after a lapse of time. Instead, we get a quick picture at all times of the exact status of all the work in the plant.

Our aim is to simplify the control of production and at the same time to get some of the benefits of a wage-incentive plan without paying a bonus or assuming the greater inspection responsibility which would be present in the manufacturing of very accurate parts on a piece-work basis.

At first this production-control plan was not looked upon favorably by our foremen, but now the majority of our shop executives are learning that the method provides an opportunity to show, through accurate record, a continually bettered performance.

Apprentice System of Lynn Plant, General Electric Company

By CHARLES K. TRIPP,[1] LYNN, MASS.

THE General Electric Company, anticipating in 1902 that future success depended a great deal upon ability to compete in the production of electrical machinery, realized the necessity of training their future superintendents, foremen, and designers along the most efficient mechanical lines. It was obvious that if they set their standard high enough to train men for these positions they also would develop good workmen.

With this in mind the company equipped a machine shop at the Lynn Works as an apprentice training room and provided classrooms where the apprentices could receive the technical education relating to their shop work. This first training room was small, and the equipment was limited as to quantity and quality; at least it seems that way today when these original quarters are compared with the present training room for machinist apprentices, which occupies some 12,000 sq. ft. on the top floor of a modern factory building and which is equipped with the most modern machinery for giving the apprentice proper experience for a mechanical career.

In the beginning there was little variety in the courses offered; today there are four major courses; machinest work, drafting, pattern making, and molding, and four special courses; sheet-metal working, steam fitting, testing, and factory business.

All courses are on a four-year basis. However, credits are allowed, not to exceed two months per year, for attaining certain educational standards and trade skill. In this way it is possible for the best apprentices to finish a four-year course in three and one-half years.

All apprentices wishing to take up the machinist trade, drafting, electrical testing, or factory business courses are required to spend two years in the training room for machinists. After they have completed their term they are given an opportunity to work at the trade for which they show the most talent, providing there is an opening. From experience we have learned that men in any of these branches are more valuable to the company when they have a good understanding of machine-shop practice.

Training Room for Machinists

The machine shop, then, is the principal training room, and it is so laid out that all apprentices start on the same class of work and under the same instructor. As soon as they have learned how to do an operation on one class of work, they are advanced to a different machine, where they will be required to do work of greater precision. There is no definite schedule of advancement in shop work. The type of work given an apprentice is determined by his ability and capacity. The great part of the instruction is traditional. The beginner is put at a machine with an apprentice who has learned to do a certain job to the satisfaction of the foreman. The apprentice acts as a teacher to the beginner, and when this beginner has learned to do the work as well as his teacher, he also acts as an instructor to another boy. Of course the boys are supervised by experienced instructors. There are twelve of these shop instructors, seven of whom are graduates of the Lynn apprentice course, and the other five are journeymen machinists selected for their production ability as well as their capacity for teaching. Each instructor has from fifteen to twenty apprentices under his supervision.

After the apprentice learns to operate the machines satisfactorily, he is given an opportunity to apply his experience in manufacturing or building a jig, fixture, or machine where he can use the experience he has acquired. If the apprentice has mechanical ability, he will be able to utilize his knowledge. It is not so much the ability to do as he is told as it is the ability to apply the fundamentals and to use his ingenuity without being specifically instructed that is important.

All the apparatus manufactured in the training room is selected from the different production and tool departments for its educational value rather than for its simplicity. As large a variety and as many different types of machines and apparatus are made in the training room as is possible to obtain in a factory manufacturing electrical machinery.

As all apparatus produced by apprentices is subject to the most rigid inspection by the general inspection department of the plant, it is necessarily of equal quality to that produced by any other department. Even under these circumstances the amount of spoiled work is small, being less than 2 per cent.

Training Room for Molder and Pattern Maker

In addition to the machine shop we have two special training rooms, one for molders and the other for pattern makers. A part of the foundry is sectioned off where all the molder apprentices receive the first year and a half training under a competent instructor. After this period they are placed among the regular journeymen and get as good work as they are capable of doing. The pattern training room is a portion of the pattern shop that has

[1] Supervisor of Apprentices, General Electric Co.

Contributed by the Committee on Education and Training for the Industries and presented at the New England Industries Meeting, Boston, Mass., October 1 to 3, 1928, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York, N. Y. All papers are subject to revision.

been partitioned off. Here the apprentices are under special instruction for the first two years of their course and are more easily supervised by their instructor than they could be if scattered among the regular journeymen.

SELECTING THE APPRENTICES

Of all the factors that enter into the training of the apprentice the selection of the proper candidates is of the most importance. In order to make a good selection it is necessary to have more than one applicant for a job and a good quality of applicants. Fortunately we have more applicants than we can accommodate and are not even obliged to advertise for apprentices. A large percentage of those who apply are relatives or friends of our apprentices or graduates. We are also getting better quality today. Twenty-five years ago it was very rarely that a high-school graduate applied for a position as machinist, but today 75 per cent of our apprentices have a high-school diploma.

Table 1 shows the average yearly registration and elimination statistics.

TABLE 1 AVERAGE YEARLY REGISTRATION AND ELIMINATION STATISTICS

Number of apprentices hired	237
Number dropped each year:	
Unable to maintain classroom standard	50
Unable to maintain shopwork standard[1]	30
Number leaving to return to school	18
Number leaving because of illness	6
Number leaving for miscellaneous reasons	54

[1] Thirty-five per cent of the number dropped from the course as not being up to the shopwork standard found positions as regular workmen in other departments in the plant.

Personal appearance is the first factor we consider in making a selection, and next come personality and character. If a boy has the proper personality and character, it is then necessary to find out if he has an aptitude for the trade he has chosen. While we attempt to predetermine by certain aptitude tests a boy's ability for any particular trade, our individual intuition is a strong influence in making a decision. After an applicant has satisfactorily passed the required entrance examination either he is hired or his application is placed on file. When he is hired he is given a printed set of rules covering his own safety as well as that of others, and also instructions in the operation and the starting of machines. While we have a very rigid entrance examination we are unable to predetermine some of the most important characteristics of the individual such as character, capacity, judgment, initiative, application, energy, and stability.

The time that it takes to determine whether the apprentice has these qualifications will vary as the individual; in some it may be only several days, in others it takes a few months. Therefore the apprentice may consider himself on probation for the full term of his apprenticeship. The fact that he signed an agreement is no assurance that he will complete the course or receive the diploma and bonus, which are only awarded for recognition of having satisfactorily completed his shop and school work.

WORK IN THE CLASSROOMS

The classroom work is divided into two sections, the engineering school and the apprentice school. The engineering school work is open to high-school graduates who can successfully pass entrance examinations in algebra, plane geometry, mensuration (plane surfaces, surfaces and volumes of cylinders, spheres, and cones), and physics (elementary mechanics). High-school graduates who cannot pass the engineering-school entrance examinations and grammar-school graduates constitute the apprentice school. Applicants to this school must pass an entrance examination in arithmetic covering decimals, common fractions, conversion of decimals to fractions and fractions to decimals, in mensuration covering areas and volumes of single shapes and in percentage and interest.

The character of the work in both schools is practically the same, the subjects ranging from fundamental mathematical, mechanical and electrical principles up through modern practice in design. The only difference between the two is that the curriculum of the engineering school is on a higher plane. In both schools great stress is placed upon the teaching of mechanical drawing, because we are of the opinion that drawing, more than any other subject, brings out the latent ability of the student along mechanical lines.

The classrooms are on the same floor as the training room and cover a floor space of 5000 sq. ft. They are arranged to accommodate about thirty apprentices each and are equipped for teaching the correlated theoretical subjects in the most efficient manner. The classroom instructors are selected not alone for their ability to teach their respective subjects, but also because of their practical endowments and experience.

STUDENT ACTIVITIES

Student activities are encouraged, and all social functions, athletic contests, theatricals, etc., are promoted under the direction of the Apprentice Fraternity. The chief function of the fraternity however, is the promotion of brotherhood among the apprentices. Their headquarters consist of an assembly hall, pool and billiard room, and officers' room. The officers are president, vice-president, treasurer, and secretary, and election to these offices is made by ballot once a year.

Social functions include installation of officers, athletic banquet, semi-monthly dances, and an annual smoke talk. Athletic teams including baseball, basketball, track, fencing, and football are supported by the fraternity, and schedules are arranged with the leading high-schools, prep schools, and college freshmen teams under the direction of a professional coach. A dramatic club stages short one-act sketches at the fraternity hall periodically and a four-act play annually.

ALUMNI ASSOCIATION IS LARGE

About 1907 an Alumni Association was formed, whose membership at present is over a thousand. Periodic meetings are held for educational and social purposes and a monthly publication, *The Alumni News*, is a means of fraternal contact. Once a year a banquet at some Boston hotel is the occasion for the gathering of the graduates who live in New England, and similar annual meetings recently have been held in other parts of the country where smaller groups can be assembled. Through the medium of this association a record is kept of the location and the position of the graduates.

The achievements of the school may be measured by the status of the 1070 graduates, of whom 550 are now with the General Electric Company. Of this number 2 are managers, 5 superintendents, 22 engineers, 20 foremen, 33 assistant foremen, 9 subforemen, 10 in the time study and cost department, and 40 are salesmen. There are 40 of the graduates teaching in trade schools or in colleges, and a large percentage are holding excellent executive and engineering positions in nearly every state in the Union and its possessions and in several of the South American republics.

THERE are today seventy-six regular air lines in Germany, including national and international lines. On all these lines there is at least one airplane a day operating in each direction, except on Sundays. The German air lines receive a large appropriation for carrying mails. This covers about 70 per cent of the total expense of operation and maintenance of the air service; the other 30 per cent comes from income from freight and passenger service.—*Machinery*, February, 1925, p. 452.

Does Mass Production Lessen the Need for Trade Skill?

By H. A. FROMMELT,[1] ST. LOUIS, MO.

Briefly, the author shows that the need for trade training has increased both relatively and absolutely because of the wholesale application of machinery and mass-production methods to modern industry; that large numbers of craft-trained men are needed for supervisory personnel; and, finally, that mass production has been and is the greatest single factor in increasing the need and demand for skill.

THERE are some persons who believe that we are to arrive at the industrial millenium by a wholesale introduction of automatic machines, with automatons to operate them. At a recent educational conference a noted educator expressed the belief that the day for vocational and trade training had passed. We were about to enter the age of push buttons, of which there would be one for every important daily task, awaiting a mere push to set in motion automatic machinery. This educator believed that the day of the skilled mechanic was passing.

The average manufacturer, of course, will be less likely to blunder as seriously in a matter of this kind. The recent revival of interest in trade training, springing largely from necessity and economic conditions, has revealed some who have objections to a formal apprenticeship. The objection most frequently on the lips of dissenters is the apparently irrefutable statement that modern mass-production methods and the almost universal application of machinery make apprenticeship entirely superfluous.

There is something so plausible in this statement that it is considered among the uninitiated as amounting to the utterance of an axiom. And yet nothing could be further from the truth. In fact, it can be stated that the wholesale application of machinery and mass-production methods to modern industry not only makes trade training an essential duty and necessity, but that because of these methods the need for craft skill has increased both relatively and absolutely.

Need for Craft Skill Increased by Wholesale Application of Machinery and of Mass-Production Methods

A little consideration will make clear the truth of this statement. Let us suppose for the moment that we stand in any of the production departments of an automobile or tire manufacturing plant. We are watching the parts or the finished product speed by us in quantities of hundreds and even thousands every day. Surely, you will say, there is no need for skill here. Yonder is a man who tends a battery of five machines. All that is needed is a first-class laborer. Here and there is an individual who is really operating a machine. He has only to drop his pieces into jigs and fixtures, tighten a few clamps, and set the machine to doing the job.

Before we leave, let us look carefully again to make certain that we are not losing sight of the trees because of the forest. Who produced the machines with which this work is being done? Many of them are of special design, or are at least equipped with special devices. Surely skill was required in their manufacture. The building in which we stand cannot be produced by mass-production methods. Likewise the electrical, heating, ventilating, lighting, water, gas, and air equipment cannot all be produced as are cylinder blocks and tires. Trade skill entered largely into the manufacture and installation of this necessary equipment.

Nor is this all. Mention has been made of the jigs and fixtures necessary in a plant of this kind. In a separate department, perhaps in a separate building, we shall discover the very antithesis of mass production. Here mechanics of the highest skill and rank are engaged in making laboriously and accurately the jigs, fixtures, gages, and templets necessary for the operators and machine tenders we saw before. The more intensive the application of production methods, the larger the department of this kind becomes.

In another department we discover the making, preparing, and servicing of the dies so necessary to our modern methods. Some classes of die makers, particularly those engaged in the fashioning of our automobile-body dies, are not only first-class mechanics but something of artists as well. With the increasing use of drop forgings the die maker becomes a much-sought-for individual.

Still further on we enter a separate department known variously as the maintenance, plant engineering, or mechanical department. Fortunately the maintenance of air, water, gas, steam, electrical, and sanitation equipment cannot be placed on a production basis. Yet in large plants that are devoted to mass-production schedules, the maintenance mechanic becomes tremendously important. Moreover, the relative size of these maintenance departments would probably surprise the average layman. Further, there is a skill required by these individuals that can come only from a thoroughly fundamental and intensive training. When an electric motor on a crane requires an emergency repair, nothing short of the ingenuity of a craftsman and the skill of a trained man is required.

In the drafting and design departments we shall generally find men who have "come up through the shop." It is surprising the number of things that can be put into a neat drawing that can never be cast and machined. A drawing under the pen of a man trained in shop methods becomes not only the representation of a piece possible of manufacture, but what is more important, the most economical to manufacture.

Back into the production departments again and we shall find set-up men necessary for these batteries of machines which before we thought were cared for only by machine tenders. To set up a machine for a long run of production requires the skill of a man who has had a far broader experience than that of a machine tender. He may not have had the training of the old-time craftsman, but he has more than the experience of a machine tender.

Craft-Trained Men Needed for Supervisory Personnel

Modern production methods have multiplied the management problems of industry many fold. In fact, the production plant has merely shifted the emphasis from manual skill to managerial skill. The task of directing men and materials requires at least a trade background and, better still, trade training. Vast numbers who have been elevated to the supervisory ranks have come from among those who in the past decades have "served time."

It is true that the supervisory personnel need not have the same training in skill that the old-time mechanic received, yet it

[1] Consultant in Industrial Education.

Contributed by the Committee on Education and Training for the Industries and presented at the Summer Meeting, St. Paul-Minneapolis, Minn., August 27 to 30, 1928, of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. All papers are subject to revision.

should be given an opportunity to acquire, through a programmatic and well-supervised apprenticeship, some of the elements and fundamentals of the new skill so much needed today.

Whole departments such as time study, plant layout, and production control, require personnel trained in the ways and manners of the shop; a personnel that must constantly base its judgments on experience such as the mechanic has acquired. True, they need not have the actual manual skill of the old-time craftsman, yet somehow they must be his kin in experience. In short, an adequate apprenticeship would be for them the best means for acquiring this experience and for industry the most economical method of developing this personnel.

Even a cursory analysis of the situation shows that the antagonists of apprenticeship systems, who have the mass-production complex, have chosen a most unfortunate example in the automotive industry to prove their contention. If we look beyond the vast industrial organizations producing individual transportation there looms before us the problem of servicing the product of these plants and the skill necessary for such service.

The contention is sometimes heard and is frequently accepted by the layman that the foolproof automobile obviates the necessity for much skilled mechanical servicing. Yet the very opposite deduction must be made, after a careful consideration of the factors involved. Foolproofing of the automobile merely relegates the tinker and wayside mechanic to the limbo of nuisances, and elevates the skilled mechanic in this field to an enviable position. When the present-day automobile is driven into a service station for attention and repairs it usually has developed some "organic disorder" which requires the skill of the mechanic if not the specialist.

It is true that we have been and are cursed with bunglers, sledge-hammer mechanics, and other incompetents in the service field, which is just another indication of the need for skill.

If all of the ordinary operations of living were to be set into motion by push buttons this very highly mechanized society would suddenly and quickly collapse. It would creak and groan and fall apart for lack of that skill necessary to service its mechanization, repair its breaks and failures, and replace its worn-out parts.

Reference has already been made to the shifting of the emphasis from purely manual skill to managerial skill, so that the latter has taken on the dignity of an art and even of a science. Mass production has waved its magic wand and called into being new trades, and even new industries. Alloy steels, die casting, and heat treating will conjure forth pictures not only of new industries and crafts, but even of relatively recent sciences of which the automotive industry has been largely the progenitor.

Mass Production the Greatest Single Factor in Increasing the Need and Demand for Skill

Mass production has both relatively and absolutely increased the need for skill. Ahead of it lies the prior necessity for craftsmanship of the highest order to produce the machinery, tools, equipment, buildings, and materials to build and operate its vast industrial plants. Imbedded in it are whole departments whose entire personnel must belong to the aristocracy of the mechanic. And beyond it lies the craftsmanship so essential to the proper service of its product.

Mass production has been the greatest single factor in increasing the need and demand for skill to the significant and astounding estimate of the National Industrial Conference Board that at the present time there should be approximately one million apprentices in training in the nation's workshops.

The machine and skill are not antagonistic. The machine merely makes possible large-scale production by indefinitely reproducing, extending, and repeating the skill of the machine. This mechanization makes possible the widespread utilization of the products of mass production, and increases the necessity for both manual and supervisory skill.

Experience in the Selection of Apprentices With the Aid of Tests

By WALTER S. BERRY,[1] WATERBURY, CONN.

THE following table gives the results of different methods of selecting apprentices at the Scovill Manufacturing Company, Waterbury, Conn.

	No. of boys	Per cent satisfactory	Per cent unsatisfactory	Per cent very poor
Hired between Sept. 1, 1923, and Sept. 1, 1925, by personal interview only	50	56	44	18
Hired between Sept. 1, 1925, and Sept. 1, 1926, by interview and tests	55	64	36	0
Hired between Sept. 1, 1926, and Sept. 1, 1927 by interview, revised scale in tests, and age	36	86	14	0

In October, 1923, the Scovill Manufacturing Company started an extensive and scientific study of selection and placement of operatives. A comparison was made of scores in several tests, age, schooling, previous employment, and interviewer's observations with various measures of success on the job such as rate of pay, earnings, foremen's ratings, and terminations.[2] A study of apprentices was a part of this general study.

For the first two years of the study all applicants were interviewed, hired, and assigned to jobs by the employment department in the regular way. Then after hiring, as their first half hour's work, they were given a series of tests.[3] These consisted of

[1] Director of Training, Scovill Manufacturing Co.

Contributed by the Committee on Education and Training for the Industries and presented at the New England Industries Meeting, Boston, Mass., October 1 to 3, 1928, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York, N. Y. All papers are subject to revision.

[2] Those interested in a complete account of the study will find in the January, February, and March, 1927, numbers of *The Personnel Journal*, articles by Millicent Pond, entitled "Selective Placement of Metal Workers." The third of these articles deals with the apprentice study.

See also Bingham and Freyd, "Procedures in Employment Psychology," Shaw, 1926, p. 162.

[3] For a brief description of the Army Alpha and Beta tests from which most of these were taken, see C. C. Brigham, "A Study of American Intelligence," Princeton University Press, 1923, pp. 3–53. Full descriptions with instructions for administering are given in Memoirs, Vol. XV, National Academy of Sciences. Government Printing Office, 1921.

several mental-alertness tests including the well-known picture-completion, number-checking, digit-symbol-substitution, geometrical-construction, arithmetical-reasoning, synonym-antonym, and analogies tests, and a muscular coordination test. These test records were then filed away until they could be checked against the employee's record of success on the job.

From Sept. 1, 1923, to Sept. 1, 1925, there were fifty boys hired into the apprentice department. A study of the data gathered showed that 18 per cent of these boys were rated as very poor and another 26 per cent as unsatisfactory, making a total of 44 per cent unsatisfactory. On a weighted scale of four of the eight tests it was found that the 18 per cent very poor apprentices all scored low, and that the best boys averaged high scores. But there were several boys who had received good grades in the tests that were marked as unsatisfactory. A discussion of the reasons for their failure on the job disclosed that they did not seem to learn the importance of accuracy in their work. A study of the errors in the different tests showed that there was a relation between errors in the number-checking test and accuracy in the shop work. A grade for accuracy in the number-checking test was therefore added to their grades in the tests. This gave a scale that seemed to promise the elimination of the unteachable and of the naturally inaccurate apprentices. It was then decided to use this scale in hiring apprentices.

Within a very short time after the new standards for hiring were adopted, the men under whom the apprentices were working in the shop began remarking that they were not getting any more hopeless apprentices. The results of the study were explained to them, and they became very much interested. Due to this interest, every one who had any part in the rating of the success of the apprentices checked up very carefully with the others all of the variables that would enter into a boy's seeming success or failure, such as condition of equipment, amount and kind of instruction, personality, etc. In this way the foreman's ratings were a composite of the carefully made estimates of several men, and were much better than the hurried ratings that we had been getting.

From Sept. 1, 1925, to Sept. 1, 1926, the applicants for apprenticeship were given the tests and those who fell below the score agreed upon were not hired as apprentices. Fifty-five boys were hired, 64 per cent of whom were satisfactory, and there were none rated as very poor.

This was quite an improvement over the group hired by personal interview only. The new group was studied with the old. On the basis of the new ratings and of the larger numbers, a new scale was formed which contained the first four and the last tests, errors in the second, and age. On the weighted scores of this scale it was predicted that a higher percentage of apprentices than before would be successful. The scale was adopted.

From Sept. 1, 1926 to Sept. 1, 1927, 36 boys were hired by the new scale. Eighty-six per cent of them were satisfactory, and none were rated very poor.

In conclusion there are two points that should be especially emphasized:

1 That on the basis of test scores and preliminary ratings of success on the job, and with a small number of cases, it was possible to eliminate the 18 per cent of total failures and to raise the percentage of successes 8 per cent.

2 When composite foremen's ratings of greater accuracy were obtained on a larger group and over a longer period, it was possible to develop a scale of weighted elements in the selective process that raised the percentage of successes another 22 per cent.

Heat Treatment of Carbon- and Alloy-Steel Castings

A LARGE tonnage of carbon-steel castings is shipped without receiving any form of heat treatment. For certain classes of service such castings fulfil all requirements and heat treatment may not be necessary.

Where quality is of utmost importance, a double normalizing treatment is employed. The castings are first heated to a high temperature ranging from 1600 to 2000 deg. fahr. This high temperature breaks up the casting structure and diffuses the segregates, forming a homogeneous structure. To refine the coarse structures resulting from the high temperature, the castings are afterward reheated to a temperature between 1475 and 1600 deg. fahr.

This treatment is quite beneficial in producing homogeneous steel, but has disadvantages in that the high temperature is severe on the furnace linings and produces scaling, and, with certain designs, warping.

After normalizing carbon castings, they may be tempered at some temperature below the critical temperature range, depending upon requirements, but 1200 deg. fahr. is usually the temperature suitable for most purposes. This tempering gives better ductility and relieves the cooling strains.

Alloy castings should, in most cases, be tempered after normalizing for the purpose of relieving the brittleness and strain caused from the air quench and also to increase the ductility and impact values.

By full-annealing castings, that is, heating well above the critical range and cooling slowly, a fairly uniform structure is secured, but not fine-grained. The structure is made much finer by faster cooling, such as air cooling, and the physical properties are higher. Full annealing is not necessary for most classes of castings, unless it be on heavy sections and for machining alloy castings.

Design and size of the casting are the governing factors in deciding upon quenching. Intricately designed castings should not be quenched, as cracks are likely to develop. These cracks often appear internally, so they are not detected until after the castings are in service. Where quenching is required the design should be such that quenching is practical.

Water or oil quenching castings develops the maximum available properties of the steel. To derive the benefits of the alloys, alloy castings should, wherever possible, receive some form of quench, either water, oil, or air.

With certain designs and with castings containing defects, there is danger of cracking from the liquid quenching. Where such dangers are apparent but a quench is necessary to develop required properties, some form of air quenching may be of help in accomplishing the desired end. Such castings may be cooled in the air as in normalizing. The furnace doors may be so manipulated that the proper rate of cooling is obtained, or the cooling may be accelerated by using an air blast, provided the design of the casting will permit. Such accelerated air cooling may also be resorted to with large castings requiring a quenching treatment.

After quenching, the castings should be tempered to relieve the quenching strains and to develop the properties required. As the tempering temperature is increased the hardness is decreased, but the reduction of area, elongation, and impact values are increased.—From abstract of a Western Metal Congress paper by J. Edward Donnellan, in *The Iron Age*, January 31, 1929, p. 342.

Elastic Failure and Fatigue Failure of Metals

Their Nature and Importance in Structural and Machine Design, Where Both Must Be Taken Into Account

By H. F. MOORE,[1] URBANA, ILL.

ONE OF the ideas which has become generally embedded in our textbooks on mechanics on materials is that of elastic limit, or that limiting stress below which a metal returns to its original shape after load is removed, and below which no damage is done to the material, no matter how often it is loaded. The experiments of Wöhler (1859–1870) and experiences of railroad engineers and later of automotive engineers and aeronautical engineers developed the fact that sometimes under repeated stress, metal parts failed under stresses somewhat below the elastic limit, as determined by careful laboratory tests. Moreover this failure was a sudden snapping off if the material was ductile. This is illustrated in Fig. 1, which shows a fatigue failure of a shaft.

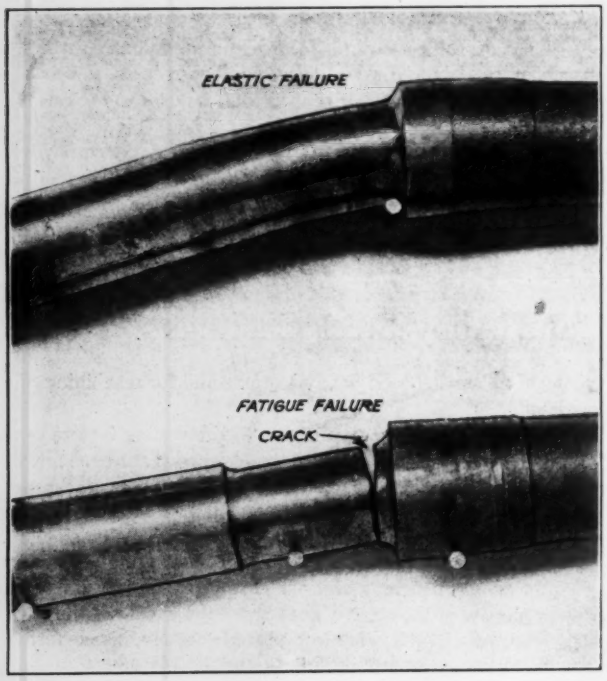


FIG. 1 ELASTIC FAILURE AND FATIGUE FAILURE OF A SHAFT

(The upper specimen failed under a single loading steadily applied; the lower specimen failed after a large number of reversals of flexural stress. Note the sharp fracture of the lower specimen as compared with the gradual bending of the upper.)

The first and most obvious explanation of this phenomenon was that under repeated stress the metal underwent some mysterious change of nature. The surface at the fracture showed rough and jagged (see Fig. 2), and the metal was said to have become "crystallized," and the name "crystallization" came to be applied to this sudden failure under repeated stress.

All this time designers of structures, which usually are not subjected to many marked alterations of loading, were finding their most serious failure in wrought iron and steel to be one due to inelastic action—most disastrous when buckling of columns or beams was caused, but serious enough when any marked

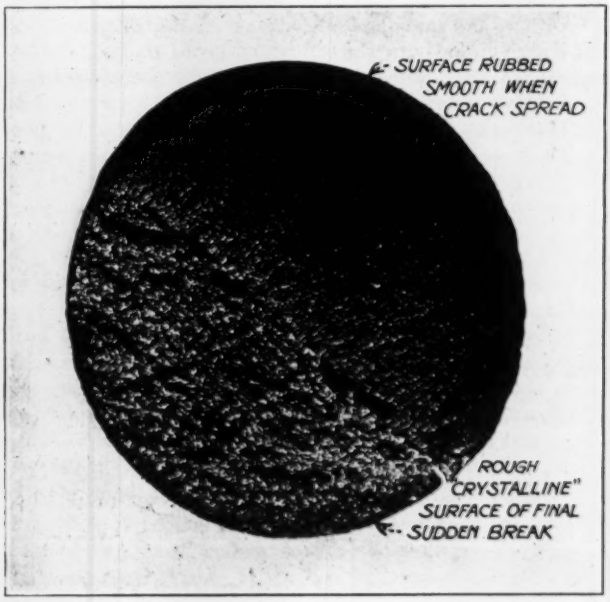


FIG. 2 APPEARANCE OF FATIGUE FRACTURE OF SHAFT SHOWN IN FIG. 1

(The shaft failed after many thousands of cycles of reversed bending. The crack started around the circumference and gradually spread inward. As it spread the walls of the crack battered each other smooth. Finally there was left only a small central area of sound metal. This could not stand further stress and failed suddenly, leaving a jagged, "crystalline" surface at the center of the shaft.)

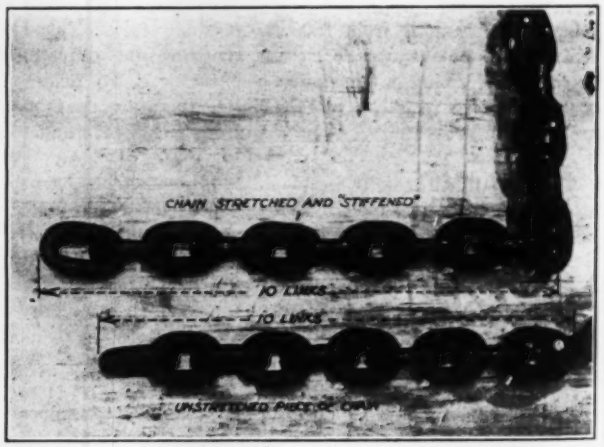


FIG. 3 ELASTIC FAILURE OF CHAIN

(The chain at the bottom is unstressed. The chain at the top was cut from the same piece as that at the top, but has been pulled until the yield point was passed, and the chain "stiffened" so that the links ceased to work freely.)

permanent distortion of the structure occurred. Chains were sometimes stretched until the links "stiffened" (see Fig. 3). Columns and struts crumpled up under loads which caused

[1] Research Professor of Engineering Materials, University of Illinois. Mem. A.S.M.E.

Presented before Section M (Engineering) at the Annual Meeting of the American Association for the Advancement of Science, New York, December 28, 1928.

inelastic yielding in the metal (see Fig. 4), and long beams sometimes failed by the sidewise buckling of the compression flange.

To the unaided eye, elastic failure becomes visible after it affects a considerable area of the machine or structural part under study. The characteristic of the failure is abnormal distortion of the part, which distortion remains after the load is removed. If the part is of rolled steel not machined, elastic failure is accompanied by a flaking off of mill scale and paint. If the piece is in tension and mere distortion does not interfere with the action, a considerable amount of inelastic action may

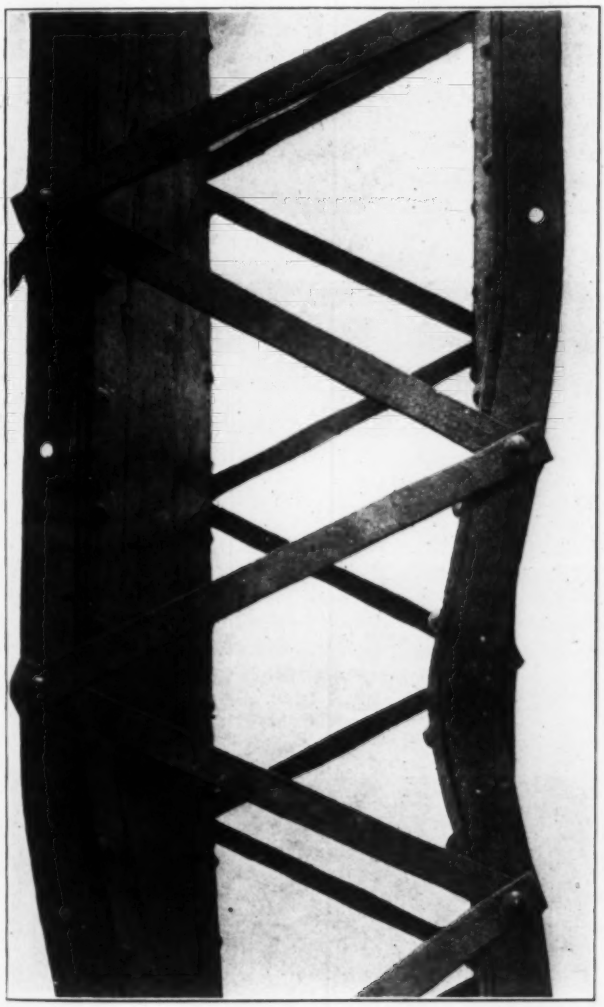
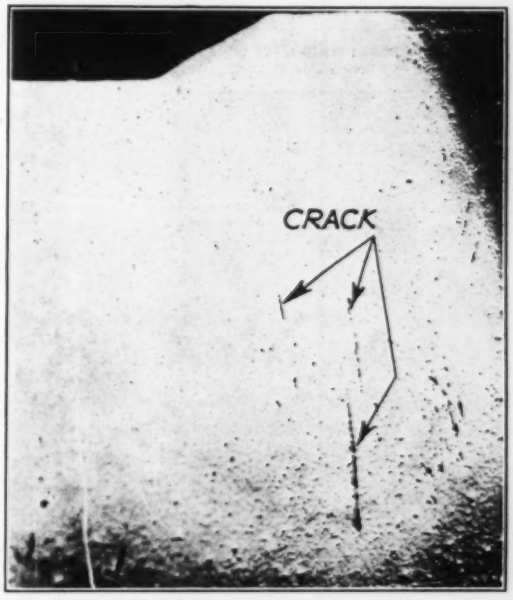


FIG. 4 ELASTIC FAILURE OF STRUCTURAL COLUMN

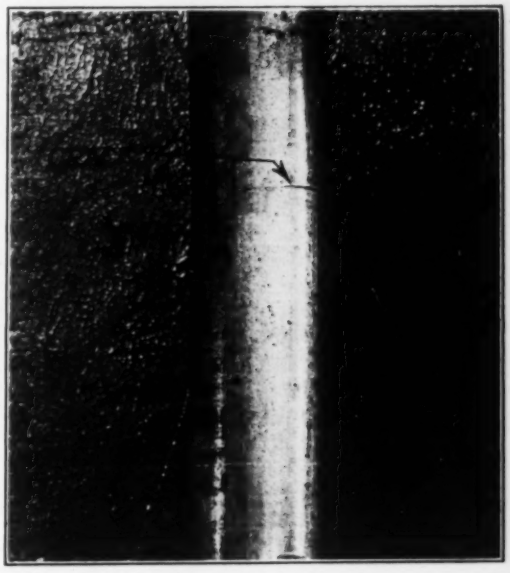
take place without serious damage. For example, many bolts are put under so high a tension by nuts that they take a slight permanent stretch. Elastic failure is more dangerous in compression members than in tension members. Under compression there is a tendency toward buckling, and this buckling is greatly magnified when the elastic limit is exceeded. Any column, even a rather short one, is in danger of collapse if any appreciable part of its cross-section is stressed beyond the elastic limit. Elastic failure in beams and shafts usually is disastrous on account of the distortion caused in the structure rather than on account of any actual shattering fracture which is set up.

FATIGUE FAILURE SUDDEN AND WITHOUT WARNING

Fatigue failure takes place suddenly, and, unless the part is very closely watched, without warning. If during the life of a machine periodic examinations of its surface are made, there can sometimes be detected a small crack (see Fig. 5) which can be seen to spread under successive periods of service, and which will result in a sudden fatigue failure very much as if



(*a*)



(*b*)

FIG. 5 FATIGUE CRACKS IN MACHINE PARTS

[(*a*) Car axle. The fatigue crack is made visible by rubbing the surface of the axle with oil, rubbing off the oil, and coating surface with whiting. The oil retained in the crack discolors the writing. (*b*) Cracked turbine blade.]

the spread of the crack were caused by the cutting action of a minute hacksaw.

This crack forms even in soft, ductile metals. The author has seen fatigue cracks in as soft and ductile a metal as Armco iron. These cracks have a tendency to start at scratches, nicks, sharp shoulders, or even deep tool marks.

With the advent of the metallurgical microscope, a flood of light was thrown on the mechanism of fatigue failure and

of elastic failure. Examination of stressed material by means of a microscope shows striking differences between these two types of failure. Fig. 6 shows the development of elastic failure in a piece of almost pure iron. The iron is shown in its unstressed condition at (*a*), seen to be made up of crystalline grains, and when stressed above the elastic limit it takes on the appearance shown at (*b*). Some of the grains seem to split up into thin plates which slide over each other like cards in a pack.

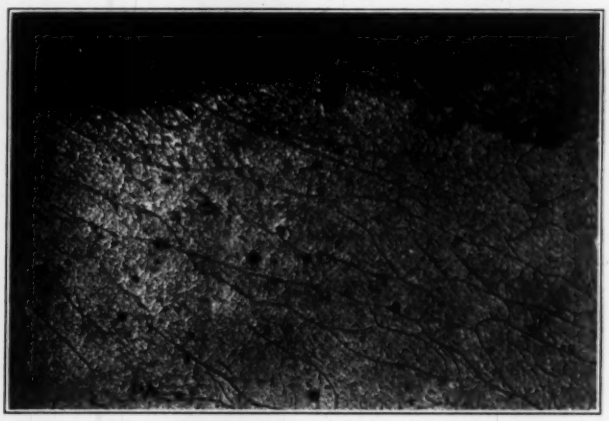
(*a*) Unstressed

(*b*) Stressed Beyond the Elastic Limit

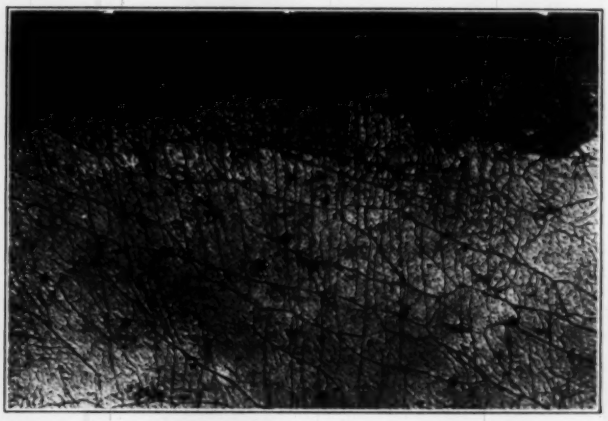
FIG. 6 MICROGRAPHS OF ELASTIC FAILURE OF ARMCO IRON
("s" shows location of slip lines. Magnification, 75×. Micrographs by J. W. Harsch, Metallographic Laboratory, University of Illinois.)

If this specimen is repolished, nearly all the little "slip lines" which mark the surfaces of the planes disappear. The material does not seem to be fractured, but merely to have certain crystalline grains distorted by slipping along planes.

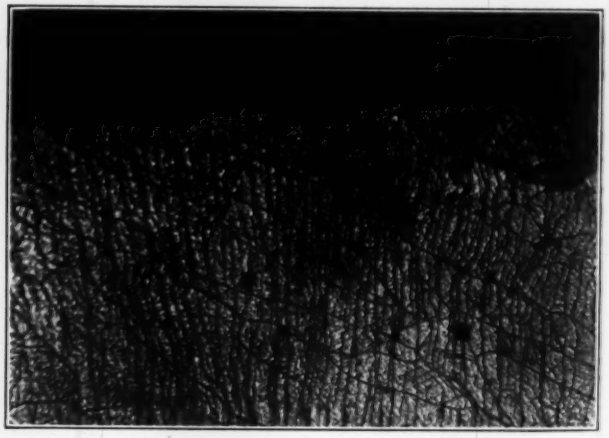
The state of affairs under fatigue failure is shown in Fig. 7. Here (*a*) shows a piece of almost pure iron unstressed; (*b*) the appearance after 27 bendings back and forth, and (*c*) the appearance after 424 bendings. The appearance of minute cracks and their spread is very obvious. These cracks differ from the "slip lines" which mark elastic failure in that they extend squarely across the grains and grain boundaries, and do not disappear after the surface of the metal is repolished. They



(*a*) Unstressed



(*b*) After 69 Cycles of Bending



(*c*) After 424 Cycles of Bending

FIG. 7 DEVELOPMENT OF FATIGUE CRACKS IN ARMCO IRON
(Magnification, 75×. Micrographs by Prof. H. R. Thomas, University of Illinois.)

seem to be actual fractures which spread with repetition of stress.

Sometimes these fractures seem to start from regions where

elastic failure has occurred. Fig. 8 is a micrograph of a fatigue crack in copper, and the disturbed area, with apparent elastic failure in the region around the crack, is quite obvious. There have been well-marked cases where elastic failure and slip occurred but fatigue cracks did not develop, although the parts were subjected to millions of repetitions of stress. The author has personally seen two cases where actual fatigue cracks started, spread a little way, and then spread no further, although the piece was subjected to many—in one case to ten million—repetitions of stress.

We do not know whether fatigue cracks ever start without some inelastic action in the region where they start. Such inelastic action would be so slight in extent that it would not appreciably affect the general behavior of the piece. In fact, a microscopic study of elastic failure leads us to the conviction that what we determine as elastic limit is merely the arbitrary location of a stress which causes an appreciable amount of inelastic action in the test piece—an amount of inelastic action so large that our measuring instruments can detect it.

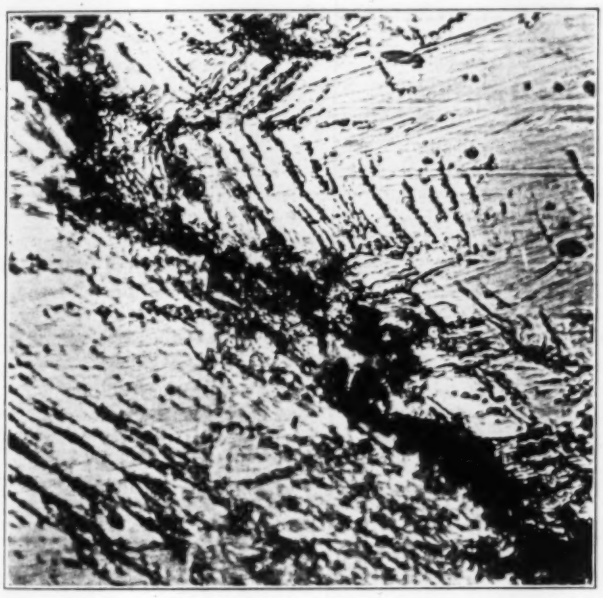


FIG. 8 FATIGUE CRACK AND SLIP LINES IN COLD-DRAWN COPPER
(Specimen unetched. Magnification, 800×. Micrograph by K. Schanbacher, Metallographic Laboratory, University of Illinois.)

ELASTIC FAILURE AND FATIGUE FAILURE RADICALLY DIFFERENT PHENOMENA

Viewed through the microscope, elastic failure and fatigue failure are radically different phenomena. Elastic failure can sometimes occur without resulting fatigue failure, but it is not known whether fatigue failure can occur without some previous elastic failure.

When we try to picture either elastic failure or fatigue failure in terms of the atomic structure of a metal, we enter at once into the field of speculation, although by his experimental study of the strength of a single crystal of metal, Gough (British National Physical Laboratory) has shown that slip seems to take place along certain definite planes of weakness in the space lattice[2] of a metal.

[2] The regularly arranged pattern into which the atoms of a crystalline grain tend to arrange themselves is called the space lattice of a metal.

Apparently slip may be pictured as the temporary rupture of atomic bonds in a metal, followed by the reestablishment of new bonds. With this disturbance, Gough follows up his experimental work by speculatively picturing a "wrinkling" along the planes of slip, with a consequent tendency to cause permanent rupture of atomic bonds. Once such permanent rupture has taken place, a minute crack has started in the metal, and under repeated stress this crack spreads due to the heavy concentration of stress which occurs at its ends.

While this picture must be regarded as speculative, it nevertheless fits the observed phenomena both for elastic failure and for fatigue failure, and may be accepted as a tentative hypothesis.

So far we have been discussing the nature and the mechanism of elastic failure and of fatigue failure. What is the practical significance of each? To the structural engineer or the machine designer, elastic failure is of significance when it tends to cause such distortion that a machine or structural part cannot function properly.

It is an assumption of mechanics of materials, at least an assumption underlying the use of the common formulas for stress and strain, that the significant cause of structural damage is the maximum stress or maximum strain. No distinction is made between a stress or strain affecting a large area (e.g., the stress in the compression flange of an I-beam) and a highly localized stress affecting a minute area (e.g., the stress at the bottom of a screw thread). For elastic failure, especially of ductile materials, high localized stress is frequently of no great significance. Thousands of bolts and riveted joints continue to function satisfactorily, although inelastic action has taken place over minute areas of their surface. For brittle materials such localized stress is more likely to cause serious damage, although the damage is always much less than would be indicated by a computation of the localized stress by the formulas of the theory of elasticity.

The ordinary formulas of the mechanics of materials are such that for ductile materials they may be used to compute the significant widespread stresses tending to cause elastic failure. In general, these formulas cannot be used for the determination of localized stress, and hence are not always adequate for designing parts subjected to many cycles of stress. The whole science of mechanics of materials has been developed largely for use of the structural engineer. In general, he deals with members subjected to steady loads. We must expect that the formulas which have served satisfactorily for structural design may require modification, and that some new methods of analysis may have to be introduced to meet the needs of the designer of machinery which is frequently subjected to repeated stress.

LOCALIZED STRESS OF IMPORTANCE IN CONSIDERING FATIGUE FAILURE

When we consider fatigue failure, localized stress at once becomes vitally important. Every minute area subjected to high localized stress must be regarded as a possible nucleus for the start of a spreading crack—a fatigue failure. In this connection the phenomenon of corrosion fatigue is of interest. If a metal be subjected simultaneously to repeated stress and a corroding medium, its fatigue strength is greatly reduced. Dr. D. J. McAdam, Jr., of the U. S. Naval Engineering Experiment Station at Annapolis, is the leading investigator in this field, and he has found that under such action there is a tendency for the corroding medium to cause minute notches in the metal. So mild a corroding agent as ordinary fresh water may reduce the fatigue strength of steel by more than 50 per cent, and the effect is relatively worse on heat-treated alloy steels than on the cheaper structural steels. The effect of simultaneous corrosion and of repeated stress is very much greater than the effect of

either of them acting alone or of the two acting at different times.

It is a curious fact that, even under repeated loading, localized stress does not seem to do as much damage as would be indicated by the more elaborate formulas of the theory of elasticity. However, in our present state of knowledge we can say only that localized stress must be considered, and that the formulas of the theory of elasticity seem to provide a safe guide.

There seems to be very little correlation between any elastic limit and any limiting stress for fatigue failure. For nearly all metals studied there seems to be a fairly well-defined limiting stress which the metal will withstand any number of repetitions, however large. This limiting stress is called the "endurance limit" or the "fatigue limit."

For any given metal the endurance limit seems to be correlated with the ultimate tensile strength of the material, although the ratio of the two values varies widely for different metals. When we remember that fatigue failure, viewed under the microscope, appears as a gradually spreading fracture, this correlation does not seem unreasonable. For wrought iron and steel there seems to be a fair correlation between the endurance limit and the Brinell hardness number.

Elastic failure and fatigue failure are both important. In our present stage of knowledge both must be considered by the designing engineer. It would be pleasant if the engineer could develop a universal criterion of strength of materials: one value, easily determined by a simple laboratory test, which would serve him whether he were designing a water tank or a crankshaft for an airplane engine. Unfortunately we have no such criterion. In fact, other factors beside elastic strength and fatigue strength must be taken into account, such as ductility, machinability, corrodibility, etc. When considering the possibilities of actual mechanical failure of a machine or structural part, both these two properties, elastic strength and fatigue strength, must frequently be considered. The solution of the design problem is, in general, not complete until both factors have been taken into account.

Research and Standardization of Cast-Iron Pipe Now in Progress

IN FORMULATING national standards for cast-iron pipe and special castings, the Sectional Committee in charge of this work has laid down a scope and program, dividing it among three technical and a considerable number of sub-committees, which in turn are each preparing a part of the specifications. These proposed specifications will be submitted to the members of the Sectional Committee for review, criticism, changes, and adoption. The three Technical Committees have been assigned the following subdivisions of the work: No. 1 on Dimensions; No. 2 on Metallurgy, Processes, and Tests; and No. 3 on Corrosion and Protective Coatings.

It will be recalled that the Sectional Committee on Specifications for Cast-Iron Pipe was organized in 1926 under the auspices of the American Standards Association, and this Sectional Committee is sponsored by the following four societies: American Gas Association, American Society for Testing Materials, American Water Works Association, and the New England Water Works Association. The Sectional Committee consists of thirty-nine men representing producers, consumers, and others having a general interest in the subject. Others have been added to the membership of the Technical Committees and their Sub-Committees, resulting in a total of over one hundred persons at work on this project.

Certain information needed by this Sectional Committee is being obtained by means of a questionnaire which has been sent to over one thousand superintendents of water and gas plants. The returns so far received show that a considerable amount of valuable information is being obtained, much of which is of a nature never before collected. It will deserve very careful study involving a large amount of work on account of its volume. The parts of the questionnaire are grouped under the following headings: 1, General information; 2, dimensions; 3, failure of pipe; 4, barrel of vertically sand-cast pipe; 5, bell and spigot joints for vertically sand-cast pipe; 6, special types of pipes; 7, fittings; 8, metallurgy and tests; 9, internal corrosion; 10, bituminous coatings; 11, cement linings and coatings; 12, soil corrosion; and 13, hydraulics. This questionnaire is soliciting views of the best men, both superintendents or operators and consulting engineers concerned with production and use of cast-iron pipe. The information being obtained may lead to changes in the present specifications before they are presented for approval as American Standards.

Under the direction of Technical Committee No. 1, trench load tests are being made at Iowa State College which will give definite information of a kind and amount never before obtained relative to some of the questions on earth loads on which there has been much discussion in the past.

Under the direction of Technical Committee No. 2, tests are under way at the University of Illinois on strength of pipe, using methods similar to those employed previously at this University by Professor Talbot, together with some new ones developed by Prof. M. L. Enger and now being used by this Committee for the first time, and these will be of great value.

These tests include: (*a*) internal pressure tests, including measurement of expansion of specimens while under test; (*b*) falling-ring impact tests; (*c*) compression tests on full rings; (*d*) compression tests on half-rings; (*e*) tension tests on half-rings; (*f*) flexure tests on rings with loads applied at six points equally spaced; (*g*) Charpy impact tests, and (*h*) Brinell hardness tests.

Under the direction of Technical Committee No. 3, tests are in progress at the Massachusetts Institute of Technology on corrosion of cast-iron pipe of various chemical compositions in water, the specimens being kept immersed up to a maximum time, under the program, of 300 days, and the water being allowed to run without interruption past the specimens which are rotated. Knowledge gained from the loss in weight of the pipe from water corrosion and from its appearance and character of corrosion, taking into account the constituents of the metal and the nature of the water, will give valuable information in regard to both pipe materials and coating.

On all of these tests the pipes come from foundries in different parts of the country and are not specimens picked for the tests but are the ordinary run of pipe, with the hope that all tests will give information which will apply to average conditions. Complete information is recorded of all details of manufacture of each piece of pipe so that everything possible will be learned to connect cause and effect of all phenomena observed. Progress reports will be published of the information available from the tests, from the questionnaire and otherwise, without waiting for the issuance of a final report, so that all information obtained will be made available to those interested as completely and at as early a date as possible. Through the generous and enlightened policies of the producers and certain of the users, over $60,000 has been made available for use in the research activities of the Sectional Committee.

Engineering Principles in the Machinery of the Stars

By A. S. EDDINGTON,[1] CAMBRIDGE, ENGLAND

THE Council of the Institution of Mechanical Engineers has taken an unusual step in appointing an astronomer to deliver the Thomas Hawksley Lecture. Perhaps the closest relations between our respective sciences would be found in the problems of construction of telescopes, particularly in the monster telescopes that are now so essential to astronomical research. For these enterprises an astronomer ought also to be a skilful engineer, but I am not qualified in that way. I come as one ignorant of the subject who can only accept with gratitude these gifts of engineering to our science. I ought indeed to be rather a pariah among you, because much of my work has been devoted to that side of modern physics which is bent on destroying the mechanical basis of the universe and showing that ether and matter are not constructed as an engineer would have devised, but rest rather on those strange conceptions associated with relativity and the quantum theory. We have been busy wrecking mechanical models and driving out the engineer. Our predecessors thought of gravitation as a stress carried by an ether of rigidity greater than steel; if you inquire about gravitation now we put you off with talk about curvature of space. The electron used to have at least something concrete about it. A year or two ago it was set spinning, and we conjured up visions of flywheels; but now we have got rid of the suspicion of mechanical contrivance, and deal with it by the mathematical device of matrices. In short, Dame Nature is no longer a bustling engineer; she is a serene mathematician.

But however unmechanical her methods, nature does contrive to produce engineering work on the grand scale, and my task must be to show you something of these achievements. While not forgetting the title of this lecture, I think it would be unwise to let it cramp us unduly, or to force continually the parallel with engineering problems. We ought to see something of the general setting in which engineering principles with others play their part. In using the terms "engine" and "machinery" in connection with stars, I am not merely offering a bait to engineers. So far as my personal work on the interior of a star is concerned, it was an engineering problem viewed from an engineering standpoint which led me to take it up. I was attracted by the problem of the pulsating stars in which mechanical energy must constantly be supplied to maintain the pulsation against dissipative forces; and I approached it from the point of view that the interior of the star must be created as a heat engine, and therefore subject to the familiar law of heat engines, namely, that in order to produce mechanical work, heat must be supplied to the working substance at a high temperature and withdrawn at a lower temperature. If there is one principle of physics which is preeminently the property of engineers, it is the second law of thermodynamics. That, as you know, is bound up with the theory of the heat engine; both its history and usage stamp it as essentially a development on the engineering side. Sometimes in astronomy we use it in a direct manner as in the problem of pulsating stars to which I have just referred. Sometimes we employ its remoter consequences. But in one form or another it has been the mainstay of astrophysical investigations, and I shall allude to it from time to time.

[1] Plumian Professor of Astronomy, Cambridge University. M.A. D.Sc., LL.D., F.R.S.

The Fifteenth Thomas Hawksley Lecture. Delivered at the Institution of Mechanical Engineers, London, February 1, 1929. Abridged.

The Sun

We may take the sun as a fairly typical star. The pressure at various depths in the sun can be calculated without much difficulty, just as the stresses in a pillar or wall are calculated. The pressure at the center of the sun is between 10,000 million and 100,000 million atmospheres; that represents the accumulated weight of the long column of material stretching up to the surface which is pressing down on the material at the center. The temperature is more difficult to calculate, and, indeed, until recently it was thought that the problem was soluble only for the so-called "giant" stars, which are much more rarefied than the sun. But we now realize that in stellar conditions matter remains a true gas even at very high densities, so that the simplifications appropriate for a perfect gas are admissible. The temperature at the center of the sun is found to be 40,000,000 deg. cent. It is a remarkable fact that our calculations give the same central temperature for the great majority of the stars. It would almost seem that there is some unknown peculiarity about a temperature of 40 million degrees; but I do not think any of the attempts to account for it can be regarded as satisfactory.

Effect of High Temperature

In dealing with these high temperatures we have to recognize that a profound change has occurred in the state of matter. The atoms are broken up—or, in scientific terms, strongly ionized. We must be careful in using the phrase "broken up," because two quite distinct atomic processes may be so described. Taking, for example, an atom of iron, it is pictured as consisting of a small, compact nucleus which contains nearly all the mass, together with a system of twenty-six satellite electrons, more or less remote from the nucleus. The nucleus is only a minute speck at the center, and it is the system of satellite electrons which balloons out the atom to the dimensions that we ordinarily attribute to it. This system is disarranged and torn by the terrific commotion in the interior of a star, so much so that most of the iron atoms retain only two of their electrons, which are held closer to the nucleus and more tightly than the others. The remaining twenty-four are loose and wander freely about in the material as though they were little atoms on their own. We should notice one point which will be important later. The big ballooning structure which gives volume to terrestrial atoms has disappeared in the star. All that is left is the nucleus with two close electrons, a structure occupying only a millionth of the volume of a terrestrial atom of iron. The twenty-four electrons when released from sentinel duty as outposts of the atom, take up practically no room as individuals.

This breaking up must not be confused with permanent transmutation of the atoms, such as occurs when radium disintegrates. However shattered the electron system may be, so long as the nucleus remains intact, the atom is still an iron atom. If the turmoil were stayed for an instant, i.e., if the temperature dropped, each nucleus would seize the right number of free electrons and make its system of twenty-six complete. The material would become ordinary iron vapor again. If, however, the nucleus is broken, a permanent change is made in the nature of

the atom, and it is no longer the same element. The temperature in the stars is, so far as we know, not high enough to produce breakage of the nucleus, and its effects are limited to the outer electron system.

THEORETICAL AND OBSERVED OUTPUT OF HEAT

Having perhaps sufficiently indicated the general line of the calculations, we pass on to the comparison of the theoretical output and the observed output of the stellar power station. You will recall that we have not been dealing with the question of fuel supply. The heat is supplied in the deep interior, we do not particularly mind how. We deal only with the manner in which the star regulates its passage into outer space. Our problem may be compared with a calculation of water supply from the pressure and diameter of the mains, which does not involve any discussion of the problems of the pumping station. We find first that the output depends on the mass of the star. Rather surprisingly it does not depend to any important extent on the density, but it is assumed that the density is not too great for the material to behave as a perfect gas.

The sun is generally regarded as a typical star; and, indeed, it is just about as ordinary a star as you could find. But the stars have great variety and range widely on either side of this type. About fifteen years ago it was realized that some stars were enormously swollen in bulk. Not containing much more material than the sun, they nevertheless fill a thousand or a million times the volume. The well-known star Betelgeuse is so great that the whole orbit of the earth could be put inside it, and its density is so low that it corresponds to that of a fairly good vacuum. Capella has a mean density about equal to air, and many other examples of the bloated "giant stars" are known. Stars of density equal to or below that of air may evidently be treated as perfect gas, and should agree with the curve calculated for a perfect gas; but the surprising thing is that these are not the only stars that fit the curve. The sun has a mean density greater than water, but it is very near the curve. Others stars have the density of iron or lead; they also fit, or if they deviate at all it is on the super-perfect side. As soon as the diagram called attention to this behavior, the explanation suggested itself. A gas ceases to be perfect when it has been compressed so much that its atoms begin to jam in contact, or when the volume actually occupied by the atoms is a considerable fraction of the whole volume of the gas. But we have already seen that the structure which swells out the volume of a terrestrial atom is broken up in the star. The tiny fragments which survive will not jam at any ordinary density. The breaking-up of atoms at temperatures of the order of 10,000,000 deg. has the effect that stellar material of the density of water or even of platinum is still a true gas.

MATTER OF HIGH DENSITY

In saying that material as dense as platinum is, under stellar conditions, a perfect gas, I mean that it still has the characteristic compressibility of a gas, namely, that if you double the pressure you halve the volume. There is nothing to prevent advantage being taken of this compressibility, so that the density need not stop at that of platinum. Under sufficient pressure a density may be reached far transcending anything known to us on the earth. There is no limit to the compressibility until the tiny fragments of atoms begin to jam, and that will not happen until we reach densities something like 100,000 times greater than those of terrestrial liquids and solids. There are two or three stars known to us which are believed actually to possess enormous densities which a few years ago seemed incredible. They are called "white dwarfs." They are intrinsically faint, giving out much less light than the sun; and yet the white color of their light and the character of their spectra show that their surfaces must be at high temperature, glowing very brilliantly. The surface is brilliant though the total light is small. This combination can only be accounted for by supposing that they are small objects. The mass or total amount of matter is found to be much the same as that of the sun; and since this has to be packed into a much smaller globe, the resulting density is enormous. The best known of these stars is the Companion of Sirius, a faint star which is visible in large telescopes and can be fully examined. The density is found to be 60,000 times that of water. A ton of its material would go inside a matchbox.

Dense material such as I have been describing must appear to us at first almost is an incredible fairy tale. But I am sure we are looking at it from the wrong attitude. You terrestrial engineers are concerned with matter in a very abnormal state. Nine-tenths of the matter of the universe—at any rate, of the matter that we are directly aware of—is tucked away in the interior of stars under temperatures of more than a million degrees. That is the normal condition of matter, and we must not take our experience of matter on this chilly little planet as at all typical.

CRYSTALLINE GAS

Those who are curious as to the possible states of matter may be interested to know that the problem of the stellar interior leads us to consider a rather remarkable state, namely, a crystalline gas. I do not think the gas inside a star is crystalline, but is it not so far removed from that condition that we can leave the possibility out of all consideration; and at any rate, material which is at the same time a crystal and a true gas seems to be possible under the right conditions.

PULSATING STARS

I come now to pulsating stars. The variable star δ Cephei is a typical example. It is a rather large star, probably about ten times as massive as the sun, and it is in a diffuse condition with an average density less than that of air. This globe swells and contracts periodically, so that the volume at maximum is about 20 per cent greater than the volume at minimum. The variation has gone on regularly with a period of $5^1/_3$ days ever since the star was first observed 150 years ago. During the contraction the inner material is being compressed and consequently rises in temperature. The adiabatic law will apply very approximately because the whole process is on so vast a scale that heat leakages are relatively small. During expansion there will similarly be an adiabatic cooling. Owing to these changes of internal temperature the outward flow of heat varies periodically and the brightness of the star waxes and wanes in the period of $5^1/_3$ days. It is this varying brightness which calls our attention to stars of this class.

This phenomenon immediately provokes the question, how is the pulsation maintained? If there were no energy to renew it, the vibration would gradually dissipate itself. The decay would not be very rapid, but there would certainly be a considerable falling off in the course of 10,000 years. Ten thousand years is a mere nothing in the long life of a star; and the fact that we find a large number of stars in this condition shows that it is not merely a transitory incident. We must look for some mechanism by which, as a star reaches a certain phase of evolution, a pulsation is started up and maintained for a long while. It will die down again when the star has evolved further, and reached a condition no longer favorable for pulsation.

There is no immediate difficulty about finding the required energy. We are bound to suppose that from some source or other heat is being liberated in the interior of the star to keep up the stream of radiation emitted into space. If only a small part of this can be diverted for use in starting or maintaining the me-

chanical energy of pulsation, it will be quite adequate. But we must here apply the principle of the heat engine. Mechanical work is only obtained from heat if there is a "working substance" taking up heat at a high temperature, and giving out heat at a low temperature. Accordingly, some part of the star must behave as a thermodynamic engine, converting heat into work according to the above condition.

Generally speaking, it is in the nature of things to acquire heat from their surroundings more readily when they are at a low temperature than at a high temperature—the wrong phase for a thermodynamic engine. That is to say, the natural tendency is to dissipate mechanical work, not to produce it. The engineer overcomes this by the use of valves, which artificially control the flow of heat. In the star the "valve" which controls flow of heat from one part of a star to another is the opacity—the obstruction to X-rays which constitute the more mobile part of the heat. The opacity depends on temperature and density, and therefore alters in the course of the pulsation. When it decreases, the effect is like opening a valve. We are therefore faced with the problem of determining which way the valve mechanism in the interior of a star is operating. Is the phase such as to admit heat into any region at the right moment and let it out at the right moment? Using the general laws of opacity so far as they are known, we have worked out this problem and the conclusion is adverse. The valves open and close at the wrong time, and increase the dissipation instead of setting the engine going. But when you come to think of it, that result is not so bad after all. Cepheid variables are the exception, not the rule; and it would have been disastrous if we had proved that the normal conditions in a star are such that the slightest provocation will start up its engine and set it pulsating.

There is another possibility which seems much simpler, but I am afraid there are grave objections to it. We believe that the heat of a star is replenished from some subatomic store of energy. Instead of worrying about the flow of heat from one part of a star to another, we can study the "valve" which regulates the supply of heat from this store. All we have to arrange is that the tap of subatomic energy shall be turned on fully when the material of the star is hottest—at the time of greatest compression—and closed when it is coldest—at the time of greatest extension. Then the star will behave as a heat engine working between these two temperatures and converting heat into work with something like maximum efficiency. Although we have no experimental knowledge of the conditions of release of subatomic energy, it seems almost obvious that the turning on and off of a tap would occur in the way suggested. If temperature has any effect at all, it will presumably stimulate liberation of subatomic energy; and if more than one atom or electron is concerned in the liberation, the increased density at the time of greatest compression will accelerate the interaction. We thus arrive at the following view: During the state of compression, the liberation of subatomic energy is stimulated by the higher temperature and density, and the star is gaining more heat than it loses by radiation. This heat gives greater vigor to the rebound from compression. During the next half-period of rarefaction, the star correspondingly suffers a net loss of heat, and this aids the ensuing return to compression. The pulsation is thus encouraged at each stage, so that a small pulsation will grow up to the greatest possible limits.

Negative Specific Heat

The problem is not so much to explain why stars are able to pulsate, but rather to explain why stars, with comparatively few exceptions, do not pulsate. We see that there is a more fundamental problem of stability of ordinary stars. The law of release of subatomic energy must be such that in general it does not upset the stability of stars. I cannot here enter into the intricacies of the problem. I will only mention one circumstance which makes it somewhat different from analogous problems in our terrestrial experience, namely, that a star has a negative specific heat.

It is our usual experience that when a body loses heat, it gets colder. Nearly sixty years ago Homer Lane showed that a star behaves paradoxically, and when it loses heat it gets hotter. It is true the deception practiced on us is rather transparent. It happens in this way. When a star loses heat—by squandering it in radiation, for example—the pressure in the interior is relaxed a little, so that the whole star contracts. But this contraction or falling in of material generates heat, converting gravitational energy into heat, and the generation of heat more than replaces the loss. The result is that internal temperature rises. Lane's law was only asserted for gaseous stars. For liquid stars the contraction would no longer be great enough to replenish the heat radiated; but we now believe that all ordinary stars are perfectly gaseous, so that the law is general. If, then, we ask how much heat must be added to a star in order that its temperature may rise by 1 deg., the answer is that no heat must be added; heat must be taken away. As Prof. H. N. Russell has put it, the specific heat is negative.

One further point may be mentioned before we leave the Cepheids. The stars differ from one another in two respects, namely, in mass and density. It appears that there is just one stage of evolution at which Cepheid pulsation is set up, so that for any given mass there is just one corresponding density which permits pulsation. Now the period of pulsation depends mainly on the density, being longest in the most diffuse stars. There is, in fact, excellent agreement between theory and observation as regards the periods. It follows that just one kind of star can have Cepheid pulsations of given period; and if we meet with a Cepheid variable of period $5^1/_3$ days anywhere in the universe, it ought to be in all respects a replica of δ Cephei. This has been stringently tested by observation. There is a definite period-luminosity law, so that as soon as we know the period of a Cepheid variable, we can say at once what its absolute brightness must be. Fortunately, the Cepheid variables are among the most luminous of the stars, and they can be observed in the remotest parts of the universe; wherever we observe them, we have at once a gage of distance. Results of the greatest interest have been found in this way by Hertzsprung, Shapley and Hubble, and our present idea of the scale of the universe is based almost wholly on this evidence. We have learned that the famous star cluster ω Centauri is 20,000 light years away, and that the light of the great Andromeda nebula which we are now receiving left it 900,000 years ago.

Fuel Supply of a Star

The question of the fuel supply of a star is one which the astronomer finds it difficult to keep away from, although there is not very much progress to record. It seems clear that the stellar furnace must be stoked from inside, not from outside. The problem is not just to maintain the radiation from the surface, but to maintain the tremendous temperature in the interior which keeps the star distended to its actual size. Thus, it is no use supposing that the sun's heat is supplied by a bombardment of its surface with meteors; you cannot maintain a temperature gradient by supplying heat at the bottem end, and the bombardment would not prevent the heat flowing away from the interior. The source of stellar energy must supply heat in the deep interior.

The principal basis for discussion was supplied by Einstein, who showed the equivalence of mass and energy. A mass of 1 gram represents an energy of 9×10^{20} ergs, and by the same proportion we at once find the total amount of energy contained in the sun or any other star of known mass. Accepting our conclusion that the heat cannot be supplied from outside, this cal-

culation gives the total store of energy which the star can draw on to provide heat for the rest of its life. The store is ample for all reasonable demands, and it would suffice to maintain the sun's present radiation for 20 billion years. But the question arises whether any considerable proportion of it is actually utilizable. There is the same enormous store of subatomic energy in the material of this earth, but it is a very remote dream that we shall ever be able to utilize it.

Most of this energy is energy of constitution of the electrons and protons of which matter is built up. If it is released, the matter must disappear. It is as though something might slip in the structure of the world, and where we had previously a proton and electron we have now only an ether wave carrying off the released energy. Is such a slipping back possible? We can only speculate. But it is not at all an idle speculation, because our whole theory of stellar evolution turns on the answer. If this energy of constitution which forms 99 per cent of the whole store is not being released, the corresponding 99 per cent of the star's mass is permanent. It seems impossible that a star can lose mass by actual escape of material anything like as fast as it loses it by radiation. Hence the star will remain of practically constant mass until the fuel supply gives out and the star becomes dead. But if the energy of constitution is releasable, the star can gradually radiate away any proportion of its mass, and big stars will evolve into little stars. There is much observational evidence which favors the view that a star grows fainter and less massive as it grows old; and this is our main ground for accepting provisionally the hypothesis that a star's heat is provided by destruction of matter inside it. But, on the other hand, there are some observational results which are hard to reconcile with this. I have already referred to the difficulty of assigning laws controlling the rate of this—or any other—subatomic process, and the fact that the simpler theories must be rejected as making the star unstable.

A Great Problem Unfolding Itself

At present we seem to be back at the beginning of the problem of stellar evolution, scarcely able to make up our minds whether faint stars are evolved from bright stars or whether they were born bright and faint, respectively. A biologist cannot have got far toward a satisfactory theory of evolution if he is still in the position of wondering whether puppies grow into dogs or whether dogs and puppies were born different. That is more or less our state today. Nevertheless, our feeling is not one of despair at the indefiniteness of present conclusions, but rather of interest and anticipation with regard to a great problem unfolding itself before us, which it seems possible to advance by many and varied lines of research. And if you should at some future date again select an astronomer to deliver this lecture, it is not unlikely that he will have much to tell of progress in the field of stellar evolution, coupled with a clearer understanding of those stores of energy held so fast and so tantalizingly within the atom.

Modern Astronomy and the Engineer[1]

A YEAR ago Sir William Bragg, in the fourteenth Thomas Hawksley Lecture at the Institution of Mechanical Engineers, discussed the X-ray analysis of metals, and showed us something of the modern physicist's work on the investigation of atomic structure. It was highly fitting that the fifteenth Hawksley Lecture delivered last Friday by Professor Eddington should be devoted to a discussion of the machinery of the stars. Sir William Bragg having taken us to one extreme outpost of science, Professor Eddington took us to the other. From a vision of the inconceivably small we were invited to pass to a contemplation of the inconceivably great. Alike, the two lectures demonstrated that nature in her workshops and power houses makes use of forces of which we, as engineers, have never dreamed, or of which, if within our ken, we have never appreciated the natural immensity. They almost numbed the mind with their revelation of the fields into which the physicist is now penetrating. They disclosed the engineer as a humble artisan in the mansion of science, endeavoring to apply the great forces of nature with little or no understanding of what they are and what is their fundamental magnitude. Could we, as engineers, work on nature's scale, we would have at our command temperatures of forty million degrees centigrade, pressures reaching up to one and a half million pounds per square inch, and velocities exceeding 180,000 miles an hour. We would find ourselves operating with bodies sixty thousand times as dense as water, with others behaving in a way which, if manifested in terrestrial substances, would lead us to conclude that they possessed negative specific heat, and with yet others which simultaneously have the properties of a gas and those of a crystal. With such temperatures, pressures, velocities, and properties at his disposal, the engineer would find himself equipped to essay tasks beside which the greatest of his achievements so far would appear trifling.

There is still much skepticism among practical people regarding the value to humanity of the work performed by the astrophysicist and his brother at the opposite end of the scale, the atomist. There are still those who, appalled by the immensity or the minuteness of the measurements involved in these two branches of modern science, willingly allow their lack of understanding to turn to complete unbelief. It is admittedly difficult to adjust one's outlook from mundane figures to distances represented by 900,000 light years—the distance by which we are separated from the Andromeda nebula—to masses of 0.9×10^{-27} gram—the mass of the electron—or to times such as 20 billion years—the length of time for which the store of energy in the sun will maintain it in existence at the present rate of radiation. But because these figures are difficult or impossible to comprehend we ought not to reject them either as unsound or ridiculous and of no value. They are the products of research as painstaking, skilled, and prolonged as anything undertaken in the name of engineering. Wrong they may be, subject to correction they probably are, but as engineers it does not become us to criticize them. That even the most transcendental of them is wholly valueless, we cannot quite believe. Astronomy and atomic physics lie at the extreme opposite ends of science, but just as the two ends of a straight line indefinitely produced meet at infinity, so do these two branches of science merge into one another. In many of its problems, modern astronomy, as all who read Professor Eddington's discourse will perceive, makes very close contact with atomic physics. Conversely, atomic physics has already drawn heavily on astronomy for inspiration. It is possible that in its higher branches the study of astronomy will in the not distant future be pursued mainly for the light which it sheds on the problems of atomic structure. Only in the heavens does nature provide us with visible means of directly observing many of the phenomena which on a minute scale are believed to be characteristic of the atom and its subdivisions.

[1] From an editorial in *The Engineer* (London), February 8, 1929, p. 159.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The Hurricane Radial-Type Airplane Motor

THIS is a valveless, carburetorless motor with only 21 working parts to the eight-cylinder model, the whole weighing under 225 lb. and developing 150 hp. at 1650 r.p.m. and 200 hp. at 2000 r.p.m. The new motor operates on the two-cycle principle, but is provided with the conventional crankcase and bearing lubrication.

There is no crankcase compression, the mixture being injected into the cylinders by a centrifugal blower built as an integral part of the crankcase and maintaining a pressure at the intake point which is increased by the piston. The elimination of all connecting-rod clusters does away with errors in timing. Each connecting rod in this motor has a separate bearing on the crankshaft which is of the two-throw type. By the use of individual connecting rods and rod bearings, it is said that the error usually caused by the angularity of the master rod on the conventional rod cluster is eliminated. (*Western Flying*, vol. 5, no. 1, Jan., 1929, pp. 68–70, 1 fig., *d*)

ENGINEERING MATERIALS

A Boiler Plant to Burn Acid Sludge

THE Atlantic Refining Company has been experimenting on burning acid sludge and similar materials since the summer of 1926. Finally, an old 135-hp. horizontal-return tubular boiler was equipped to burn this material. For this it was provided with a feed plate and a set of pinhole grates inclined toward the rear. The equipment was hand operated and the sludge was shoveled by hand to the feed plate, and after it was coked it was pushed along the grate by hand. After this operation proved to be successful an inclined-grate stoker of the rocking-bar type was installed under the boiler. To do this it became necessary to raise the boiler several feet above the original setting to get the furnace volume necessary for smokeless combustion. The front or feed end of the stoker was provided with a coking plate, over which was suspended an ignition arch. The dimensions of the coking arch were found to have an important bearing on the solution of the problem.

In the operation of this equipment the sludge is pushed from a hopper to the coking plate by mechanical pushers, where it remains sufficiently long to be coked. After the material is coked, it is pushed from the plate to the inclined grate, down which it is fed by the rocking motion of the grate bars. Ash relatively free from carbon is delivered to the ashpit. This equipment has been operating for over a year. With this arrangement no auxiliary source of heat is required for the purpose of maintaining combustion. The equipment will also burn bituminous coal, either alone or mixed with sludge. Its present performance is as follows:

Boiler rating	175 to 200 per cent
CO_2 in stack gases	10 to 13 per cent
Furnace temperature	2300 to 2650 deg. fahr.
Flue-gas temperature	500 to 600 deg. fahr.

A new boiler plant consisting of two 352-hp. water-tube units is now being constructed, the furnace and stoker design being based entirely on information obtained from the experimental unit on the horizontal-return tubular boiler. This plant will be used exclusively for disposal of refinery sludge and other waste products at a rate of 100 tons per day, and provision is being made to install a third unit later if required. (Eugene P. Kiehl, Power Engr., the Atlantic Refining Co., in *National Petroleum News*, vol. 21, no. 3, Jan. 16, 1929, pp. 65–66, 2 figs., *d*)

Tensile Strength and Hardness of Metals

SINCE the invention of the Brinell test for hardness there has been a consistent effort to determine whether or not there is a definite law relation between hardness and tensile strength. A certain relation was empirically established for steel, but there was no definite evidence as to whether that relation applied to other metals or was merely incidental to steel alone. Later it was observed that in the case of aluminum and its alloys the same relation obtains as in steel, which led investigators to the belief that possibly the deviations from that relation in the case of other non-ferrous metals might be due to the uncertainty of the hardness units obtained from the ball test.

As a matter of fact, the ordinary Brinell hardness does not indicate any property of the material, and in order to measure hardness one should resort to Meyer's law, according to which $P = a\ d^n$, where P is the load in kilograms on a ball D mm. in diameter; d in mm. is the diameter of the impression, and n is an exponent which for the same material and rigid balls is assumed to be independent of the size of the ball. It may be remarked in this connection that according to Kürth the value of n decreases with increasing cold work, and hence expresses the degree of cold work. If now we express the elongation line in tension by an expression of the form $\epsilon = (\alpha\sigma)m$, a relation may be found between the exponents m and n and the magnitudes a and α. Here, however, "hardness" measures the same resistance to flow with which we deal in the tensile test, and the property of matter comprised by hardness is nothing else than this very resistance to flow—expressed, however, not by a hardness number but by the hardness coefficients a and n.

According to Meyer, the value of a depends on the size of the ball used and shows for a given ball at what load the diameter d of the impression will be 1 mm. The elongation line rises the steeper the larger the value of n and the smaller that of m. Since cold work raises the elastic limit, m must become larger and n smaller, which explains certain well-known facts. The exponent n therefore expresses the average ability of the material to increase in strength, and the greater its value the more rapidly the strength of the material rises. The relation between tensile strength and hardness becomes apparent from the hardness coefficients a and n and is also dependent of the elongation. But within certain limits the influence of uniform elongation may be considered as secondary. A linear relation between tensile strength and hardness coefficient in the case of non-ferrous metals is impossible, because of the great degree of dependence of the conversion coefficients on the degree of cold working. These conversion coefficients in the case of non-ferrous metals lie between 0.3 and 0.6, whereas in the case of steel they range only between 0.3 and 0.4. The high values apply to the annealed state and are due to the fact that in annealed non-ferrous metals the yield point is very low when con-

sidered with respect to the tensile strength. Because of this the stresses in tension increase very rapidly with the elongations, while in the case of hardness curve the hardness coefficients increase very rapidly with the depth of impression or with the load. Because of these great increases in the values of the respective magnitudes, the ordinary depths of impression in the ball test are insufficient to increase the tensile strength (and hence coefficients of hardness) to such a degree that they would be equivalent to the increases in strength obtained in the case of a tensile test. In other words, where the ratios of yield points are small, which means that the values of n are high, the ratio becomes great.

From numerous tests the relation $K_z = af(n)$, where K_z is the tensile strength, was derived graphically. This formula and the curves in the original paper make it possible to take two ball impressions produced with different loads and, by means of a slide rule, to determine from a table the tensile strength to within $\pm$ 5 per cent. Simultaneously the exponent n is found and hence the ratio of the yield points. Should it be found that n is less than 2.2, the Brinell hardness values will be only slightly dependent on the load on the ball, and in the case of non-ferrous metals $K_z = 0.36\ H_B$, where H_B denotes Brinell hardness, is sufficiently exact.

This relation, which is known to hold for steel, is based on the yield point, which is high even for the annealed state, thus requiring a flat rise of the elongation line and low values for n. Since the yield-point ratio is high also for heat-treated aluminum alloys and in part for pure aluminum, these non-ferrous metals show a behavior in accordance with the above formula for steel. Tests made with copper and steel at higher temperatures have shown that the same formulas hold good also at those temperatures and that fundamentally there is no material difference in this respect between steel and non-ferrous metals. The author by his own tests and tests of others has even established the fact that there may be a close relationship between tensile strength and hardness even for cast metals. (Dr. of Engrg. Otto Schwarz in *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, published by the Verein Deutscher Ingenieure, no. 313, 1929, 34 pp. including 20 tables and 51 figs., *etA*)

Calcium Chloride as an Accelerator in Cement Setting

THE Groznepht Section of the Russian Soviet Government Administration of Oil Fields uses cement extensively for closing up boreholes, and the matter of acceleration in setting is to them an important one. In the past they have used a trade-marked accelerator obtained from the United States. This material laid down at the oil field cost about $30 per 220 lb. An analysis of the material indicated that it consists essentially of calcium chloride 76.13 per cent and water 23.87 per cent. The local administration made experiments on the use of calcium chloride obtained as a by-product in coke-benzol production carried on by another department of the Soviet Government. Its cost laid down at the oil field proved to be about one-fifth of the American product, but its analysis showed 37.89 per cent of water and the rest calcium chloride.

An extensive series of tests was carried out and it was found that when the same relative quantities were used the Russian calcium chloride delayed the process of setting and lowered the ability to resist strains more than the American accelerator. Incidentally it was found that when a normal amount of water was present an increase in the proportion of the accelerator reduced the strength of the test pieces. This was particularly noticeable when the American accelerator was used, and is ascribed to its lower content of water. In all the tests it appeared as if the setting and hardening of the cement took place with insufficient water, and in order to obtain with the Russian calcium chloride the same results in respect to setting and hardening the cement as were obtained with the American accelerator, the amount of calcium chloride used had to be correspondingly increased. This is illustrated in the original article by a calculation applied to a given case. (B. N. Korepanoff and E. K. Machinski, of the Science Experimental Institute of the Groznepht; abstracted through *Neptyanoe Khozyaystvo* (Russian), vol. 15, no. 1112, 1928, pp. 633–635, *pe*)

HEATING AND VENTILATION

Moderator System for Varying Heating-Steam Supply

DESCRIPTION of the new Webster moderator system, designed to give automatic variation of supply of steam and so arranged as to give convenient manual variation.

The amount of steam delivered to all or any part of a heating system is dependent on the difference in pressure between the point from which the flow starts and the point at which it terminates, together with the resistance to flow existing between the two points. The Moderator system is designed to control

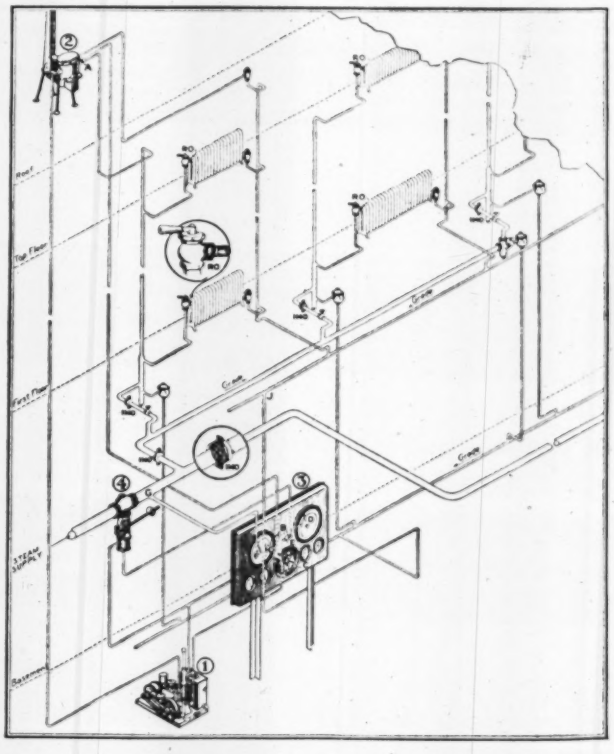


FIG. 1 DIAGRAMMATIC ARRANGEMENT OF ELEMENTS IN THE WEBSTER MODERATOR SYSTEM

steam flow by predetermining and maintaining as closely as practicable these differences in pressure throughout the system.

How this is accomplished is shown in Fig. 1. An air-circulating system produces continuously and automatically just ahead of point B an air pressure equal to the pressure difference which should exist between the supply and return mains of the heating system. The air compressor 1 in the basement maintains a constant pressure on a small air line leading to the roof thermostat 2. The amount of air flowing past the valve of the roof thermostat 2 and into the line A-B is varied by changes in outdoor temperature. This air is continuously discharged to the atmosphere at B through a restricted opening, with the result that a certain pressure is maintained just ahead of B. When the

temperature decreases, the amount of air flowing into line *A-B* increases and the pressure head of *B* is correspondingly increased. When the temperature increases, the amount of air flowing into *A-B* decreases and the pressure ahead of *B* is correspondingly decreased.

In the Webster Moderator system the resistance to flow is made up of two elements: a small element due to the friction of pipe and fittings, and a large element due to the installation, in series, of restrictions called "metering orifices," located at selected points throughout the system. The total resistance of these metering orifices is proportionately great and the resistance due to pipe friction small, so that the metering orifices largely determine steam flow.

Provision is also made to meet automatically changes in demand for steam resulting from a number of causes, such as shutting off or turning on radiation, or from variation of pressure ahead of the main steam-control valve. As at present developed the system is adaptable to the heating of buildings requiring 10,000 sq. ft. or more of radiation, but equipment suitable for the requirements of smaller buildings is said to be under way. The new system should not be confused with a temperature-control system as the latter can be produced only by the thermostatic control of radiators. (*Power Plant Engineering*, vol. 33, no. 3, Feb. 1, 1929, pp. 193–194, 2 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Marine Engineering: German Precautions Against Explosions on Diesel-Engined Vessels: Aeronautics: The Hurricane Radial-Type Airplane Motor)

The Doxford Opposed-Piston Oil Engine

WILLIAM DOXFORD & SONS, LTD., Sunderland, England, are well known as builders of large marine oil engines. They have now placed on the market a small marine prime mover having some interesting characteristics. It is a two-stroke-cycle, airless-injection type with a compression pressure of about 425 lb. per sq. in., capable of starting from cold without preliminary warming up. The engine has three working cylinders 400 mm. (about 15¾ in.) in diameter, and the combined stroke of the two pistons is 1300 mm. (51¼ in.), the engine having a designed output of 650 b.hp. at 125 r.p.m. The engine is of the differential-stroke type, the lower piston having a stroke of 760 mm. (29.9 in.) and the upper one a stroke of 540 mm. (21.25 in.). Owing to the small size and relatively short overall length of the engine, the crankshaft is arranged in one piece instead of employing separate bolted-up sections for each cylinder unit.

Each cylinder is provided with two diametrically opposed fuel valves, each actuated from a camshaft on either side of the engine immediately below the fuel valves.

An innovation of design was introduced in the camshaft drive which is now effected by a train of spur gears instead of the usual vertical shaft and bevel gearing.

As would be expected in a small engine of this type, the majority of the dependent auxiliaries are engine-driven. The single double-acting reciprocating scavenge pump is arranged at the back of the engine, being driven by means of rocking levers and short links from the crosshead of the center cylinder. Immediately below the scavenge pump, and driven therefrom by means of an extended tail rod, are placed the jacket-water pump, piston-cooling-water pump, forced-lubrication pump, and in the marine pattern, two sea-water pumps.

The weight of the three-cylinder engine, excluding the thrust block and thrust shaft, circulating and other pumps, is about 74 tons, while it should be noted that the overall length and the extreme height required for overhaul are not excessive. With the engine developing 665 b.hp. at 140 r.p.m., the test-bed specified fuel consumption was about 0.363 lb. per b.hp. per hr., while at 150 r.p.m., when the engine developed 820 b.hp., the consumption was reduced to 0.358 lb. per b.hp. per hr. As indicative that the rating of the engine is strictly conservative, it may be said that the first engine of this new type developed no less than 1100 b.hp. at 250 r.p.m. on its trials. At this output and speed the operation of the engine was very steady, the fact that the builders have paid particular attention to the question of balance, coupled with a very stiff construction of bedplate and main framing, being responsible for this result. (*The Power Engineer*, vol. 24, no. 274, Jan., 1929, pp. 25–27, 3 figs., *d*)

MARINE ENGINEERING

Pulverized Coal on the "Hororata"

THIS steamer was built in 1914 by Wm. Denny & Bros., Ltd., for the New Zealand Shipping Co. It has been lately equipped with the Howden-Buell system of pulverized-fuel burning. The ship is of 11,243 gross tons, twin-screw, quadruple-expansion-engined, and is equipped with Scotch marine boilers. Very few alterations had to be made on the boilers, the most important being the fitting of new furnace fronts which accommodate the short-flame pulverized-fuel burners.

The pulverizers are located in the forward cross-bunker. The coal is fed by hand through a grate of about 3-in. mesh, whence it is conveyed to a crusher which reduced it to a size suitable for the pulverizing plant. There are three pulverizers of the Fuller-Bonner ball-mill type driven by small turbines. The burner is of the triple-flow type, and the fuel is injected to the furnace between two bodies of air, one external or primary, and the other internal or secondary; this latter is supplied from the ordinary Howden heater. The furnace front has an inner chamber in which the secondary air is heated to a very high temperature and mixes with the primary air and fuel in such a manner as to give very rapid and complete combustion. Some data on test runs are given in the original article. (*The Marine Engineer and Motorship Builder*, vol. 52, no. 616, Jan., 1929, p. 19, 1 fig., *d*)

German Precautions Against Explosions on Diesel-Engined Vessels

AS A RESULT of the accident on the motorship *Kungsholm* in which several persons were killed and others injured, the Hamburg Engine and Boiler Supervising Board has drawn up new regulations for the prevention of explosions on oil-engined ships. These regulations include the following provisions:

As explosive gas mixtures may be formed in the closed-up parts of oil engines, special care must be given to these, particularly the crankcase. It must be assumed that oil gases contained in the crankcase will expand into the engine room if the engine is heated up or if the covers of the crankcase are opened. It is therefore necessary to provide adequate ventilating arrangements, by which gases formed in the crankcase may be led away. These ventilators must end at non-dangerous points and must be fitted with Davy safety wire gauze. The crankcase should be tight against the engine room. It is also necessary to arrange efficient engine-room ventilation in order that the engine-room personnel may not be exposed to the influence of oil vapors or burnt gases if glands or pistons are not tight. The ventilation must extend to all parts of the engine room, including the lower and covered-in parts, and should be effected by ventilator pipes going through the floor plates.

As the heating of bearings may also lead to the ignition of inflammable gases in the crankcase, care must be taken in the con-

struction and lubrication of the bearings so that excessive heating is avoided as far as possible. Lubricating oil collecting in the crankcase must be led off by the shortest-way enclosed piping to the lubricating-oil collecting tank. If the pistons of the engines are cooled by oil, this oil must be led from the expansion joints in closed piping to the collecting tank. Oil dripping from other parts in the engine room must not be led into the crankcase or into the collecting tank for lubricating oil, but to a special waste-oil collecting tank, from which it should go to the separators to be cleaned for reuse.

In no circumstances is oily bilge water to be left for any long time in the bilges or to be pumped overboard without being cleaned.

The storage and use of light inflammable oils (with an ignition point below 70 deg. fahr.) in the engine room is not to be permitted. If the use of such oil cannot be avoided, a special room must be provided for the work. This room must be separated gastight from the engine room and be fitted with special ventilation. The electrical installation in such a room must comply with the regulations for electrical installations in rooms exposed to the danger of explosions, and good fire-fighting equipment must be provided. (*The Times Trade and Engineering Supplement*, vol. 23, no. 548, Jan. 5, 1929, p. 423, *p*)

MOTOR-CAR ENGINEERING

Karrier Six-Wheeler Truck Springing

THE Karrier Motors, Ltd., Huddersfield, England, has built a series of six-wheeler trucks for use in the British Colonies. Among its features is a lengthened wheelbase, permitting a larger body to be carried with a minimum of overhang, so that the machine is able to extricate itself from ditches and rough ground without fouling the rear of the body work. The most important features of the new design, however, is the adoption of a front springing of the transverse swiveling type, which provides extreme freedom of front-axle movement and enables the vehicle to cope successfully with the most difficult stretches of country. This system of springing allows a difference in height of 22 in. between one front wheel and the other without imposing any frame deflection.

The axle beam takes the form of a heavy-gage steel tube, to which flanges are secured at the extremities for carrying the radius rods, the transverse spring anchorages, and the swivel axle pins for the front wheels. Mounted solidly on the front cross-member of the frame is a large central fulcrum bracket, providing the trunnion for the transverse spring of the front axle, one end of the spring being attached to the axle, and the other free to slide. The front axle is positioned with respect to the frame by means of radius rods, fixed solidly to the axle at their forward ends and anchored to the frame at the rear ends by large-diameter spherical bearings carried in brackets attached to the side members. While extremely simple, this form of construction gives a wide range of tilting movement and eliminates risk of frame distortion. (*Motor Transport*, vol. 48, no. 1243, Jan. 7, 1929, pp. 21–22, 4 figs., *d*)

Carbon Monoxide from Automobiles Using Ethyl Gasoline

THE Bureau of Mines in cooperation with the Ethyl Gasoline Corporation has completed a series of tests to determine whether any significant difference exists in the carbon monoxide content of the exhaust gas produced by an internal-combustion engine when its fuel is changed from straight gasoline to the same gasoline containing ethyl fluid whose active ingredient is tetraethyl lead. Three series of tests were run. In the first series the tests were made with the engine running at a speed of 1000 r.p.m. Upon changing from one type of gasoline to another during any particular test, the maximum variation in carbon monoxide content of the exhaust gas did not exceed 0.2 (which is the possible error of the analytical method used); neither did the content of any other constituent of the exhaust gas show significant variation according to the type of fuel used. In some instances there was a small difference in the gasoline consumed per unit of time as well as in the brake horsepower developed. However, the amount of carbon monoxide per horsepower-hour, as given in the last column of the table, bears out the same statement as given for variations in composition of exhaust gas—namely, that with few exceptions the relatively small differences found were independent of the type of fuel.

At the completion of this first series of tests the engine head was planed down an additional $^1/_{16}$ in.—in all $^5/_{32}$ in. was removed from the standard head. With a gage attached to this head, as previously described, a pressure of 105 to 110 lb. per sq. in. was indicated. An electric heater was attached to the secondary air inlet of the carburetor, and the air admitted was heated to approximately 195 deg. fahr. The engine was operated on succeeding tests with a cooling-water temperature of 170 deg. fahr. as compared to 150 deg. fahr. on the previous tests. These temperature alterations in the test conditions for the second series of tests were made with a view to increasing detonation.

The results of the second series of tests are in accordance with those obtained in the first series of tests. No significant variation in the composition of the exhaust gas nor in the amount of carbon monoxide per horsepower-hour was found upon changing from straight gasoline to ethyl gasoline.

Tests were made at full load only, as audible detonation did not occur at three-quarters load with any carburetor adjustment.

While ascending grades, automobile drivers generally retard the spark to decrease the detonation caused by the use of straight gasoline: as this practice is unnecessary when ethyl gasoline is used, a third series of tests was conducted with a view of simulating these conditions. In other words, tests were made at full load, using straight gasoline, with the spark retarded to a degree which caused audible detonation to cease; then, as in previous tests, the fuel was changed to ethyl gasoline and the spark advanced to the point where maximum power was developed. With the exception of the changes in spark timing, these tests were conducted in the same manner as those previously described. The engine head used was that which gave the highest compression pressure (105 to 110 lb. gage pressure per sq. in.), the intake air was not preheated, and the cooling-water temperature was maintained at 150 deg. fahr.

As in the previous tests, no significant change occurred in the composition of the exhaust gas upon changing the fuel from straight gasoline to ethyl gasoline. However, the amount of carbon monoxide produced per horsepower-hour was approximately 5 to 7 per cent less when operating on ethyl gasoline than when using straight gasoline. (W. P. Yant and L. B. Berger in *Reports of Investigations, Department of Commerce, Bureau of Mines, Serial No. 2908*, January, 1929; printed by permission of the Director, U. S. Bureau of Mines, 8 mimeographed pages, *e*)

POWER-PLANT ENGINEERING (See also Heating and Ventilation: Moderator System for Varying Heating-Steam Supply; Steam Engineering: Influence of Water Globules in Steam on Turbine Performance)

An Unusual Emergency House-Turbine Installation

THE drive of turbine auxiliaries has passed through several stages. The first was motor drive. This was replaced by independent units, such as small turbines. The weakness of this

form of drive brought on a return to motor drive, which, in its turn, was replaced by the house turbine driving a generator, the sole duty of which was to supply current for the auxiliary drives. At first the house turbine was completely independent; next, it was made to float on the line with the turbine running idle and the governor adjusted so that at a predetermined small drop in frequency the turbine steam valve would open and thereby automatically transfer the load to the standby unit. This involved certain losses which, while not very serious, were undesirable. A search for a solution of the problem led to the rather unusual emergency house turbine installed at the Philadelphia Electric Company.

This unit is of 2000 kw. capacity and consists of a turbine driving a generator and direct-connected exciter at 3600 r.p.m. It is arranged to operate with steam of 375 lb. gage pressure and 233 deg. fahr. superheat, and to discharge against a back pressure of 18 lb. abs. The equipment was placed in service at the beginning of 1926. It has been used only once in an actual emergency, but is tested weekly and has established an excellent record.

A sectional view of the turbine is given in Fig. 2. The energy converter is a single row of blades mounted on the periphery of a solid disk, to which are bolted two stiff shaft ends resting in bearings of unusual size for a unit of this capacity.

The speed of the unit is controlled by means of a highly perfected flyball governor. The fulcrum points are knife edges; relative motion is provided between parts required to have sliding contact, in order to overcome the friction of rest; and copious lubrication of all moving parts is insured by direct passage from the oil pump which is located in the bottom of the oil reservoir

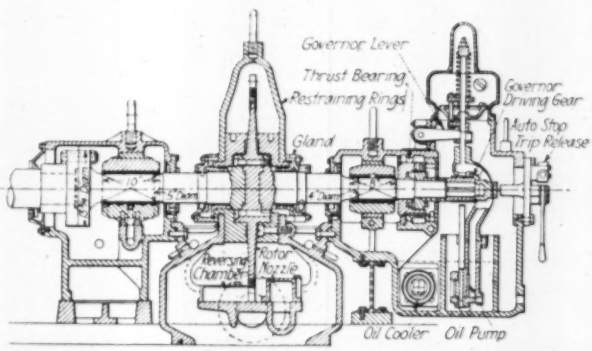


FIG. 2 SECTIONAL VIEW OF NEW EMERGENCY HOUSE TURBINE

and driven by an extension of the governor spindle. Overspeed protection is provided in the form of an eccentric-weight shaft governor of conventional design.

Not content with these customary safeguards, the designers have provided an extra safety feature for the purpose of preventing injury to the operators in the highly improbable contingency of failure of both the normal speed-control devices. This additional protection comprises two interrelated features. One is a heavy forged-steel restraining ring at either side of the rotor disk, shaped to enclose the shaft hubs and bored to provide a clearance around the shaft, sufficient for normal operation, but small enough to bring about rubbing contact if the rotor becomes seriously unbalanced. The other is the provision of means for producing such rotor unbalance should the turbine for any reason reach a predetermined limiting speed. This is accomplished by fastening two blades, 120 deg. apart, with pins of material weaker than that employed in the remainder of the fastenings.

Provision is made so that the rotor cannot attain a dangerous speed, even if both control mechanisms should fail to operate. The features of greatest interest, however, are the means provided for starting a unit in an emergency. These comprise a motor-driven auxiliary oil pump, a motor-operated valve in the steam supply line (in addition to the usual quick-closing throttle valve), and suitable electrical controls for starting the auxiliary oil pump. This pump may be also started manually by closing one of four push-button switches located in various parts of the plant. The unit is automatically started when the pressure produced by the motor-driven pump attains a certain value. As the turbine comes up to normal speed, the governor takes control of the steam admission in the usual manner. It is found that this turbine is started and is ready to be synchronized and put on the line in from 15 to 17 sec. As long as the boiler room continues to provide steam, the turbine will take care of the auxiliaries. (J. D. Schmidt, Engineering Department, So. Philadelphia Works, Westinghouse Electric & Manufacturing Co., in *The Electric Journal*, vol. 26, no. 1, Jan., 1929, pp. 26–28, 2 figs., *d*)

The Foster Steaming Economizer

AT THE beginning of 1928, E. Green & Son, Ltd., Wakefield, England, purchased the British Foster patents and goodwill. The first change that was made in the construction was the elimination of the cast-steel connector boxes which were utilized to join the tubes in each adjacent horizontal row. These connector boxes had a square section, and the tubes were expanded into them through suitable handhole plugs. The disadvantage was that the material was cast steel, which is frequently unreliable, and furthermore they produced high pressure drop, which meant more power in the feed pumps.

The new style of connection adopted is shown in Fig. 3 (one of three figures in the original article) and consists of a forged steel bend connected to two Foster elements by means of flanges and a mild-steel ring which is located between the end of the tube and the end of the bend. On pulling up the bolts the spherical faces of this ring are forced into contact with the angular faces of the tube and bend, making a perfect joint.

The latest development of the Foster economizer is that known as the steaming economizer. Foster steaming economizers are now being erected at the plant of the Synthetic Ammonia and Nitrates, Ltd., at Stockton-on-Tees, six of these machines being supplied, each with a heating surface of 23,000 sq. ft. to operate at a pressure of 850 lb. per sq. in. Two others are being supplied to the Derby Electricity Works in connection with the new extensions, and a further one to the Leicester Electricity Works for the new Freeman's Meadow Station.

If in a water-tube boiler the temperatures of the gases between every row of tubes from the furnace to the boiler outlet are taken and plotted against the boiler surface passed over by the gases, a curve of definite characteristics will result. On examining one typical curve it was observed that the gases entered the first row of boiler tubes, that is, at zero percentage of boiler heating surface, at a temperature of 2800 deg. fahr. This figure, of course, is dependent on the CO_2 contents of the gases and the type of furnace used, but is a good average.

After the gases passed over 10 per cent of the heating surface their temperature had fallen to 1850 deg. fahr., and after they had passed over 100 per cent of the surface, in the case of the boiler from which the curve under consideration was taken, they had fallen to 650 deg. fahr.

Further, in this case the gas temperature dropped from 2800 deg. fahr. to 1050 deg. fahr. after the gases had passed over 50 per cent of the boiler surface. In other words, the first half of the boiler reduces the temperature of the gases by 1750 deg. fahr. The second half only reduces the temperature of the gases by 400 deg. fahr., and consequently the heating surface of the first half is doing approximately four times the work of the heating surface of the second half of the boiler, the reason of this being that the mean temperature difference between the gases and the water in

the first half of the boiler is much greater than in the second half, and furthermore, due to the fact that the gases are cooling, the velocity of the gases in the first half is frequently greater than in the second. The latter consideration, however, is of minor importance compared with the former.

If the velocity of the gases in the second half of the boiler could be increased, the rate of heat transference would be increased, and the boiler would do more work. This, however, entails complicated baffling, which is not desirable. The only other means of

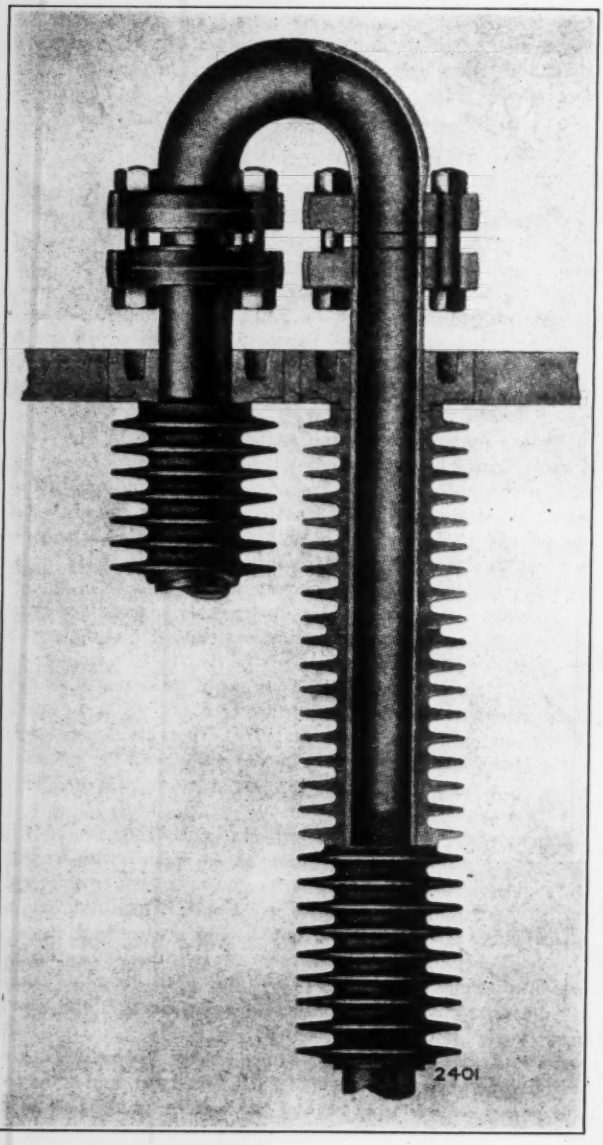


Fig. 3 Foster New-Type Bend

increasing the work done is to increase in some way the mean temperature difference between the gases and the water. This, however, is impossible in the ordinary boiler because all the water in the boiler is at the same temperature. If, however, the heating surface in the last half of the boiler is eliminated and replaced by Foster surfaces, a great advantage is obtained. To do this the firm installed a Foster steaming economizer of half the normal surface behind the boiler, and the gases then would enter this steaming economizer at a temperature of 1050 deg. fahr.

Now, in the economizer, gases and water are flowing in an opposite direction, and due to this, and to the fact that the feedwater is entering the economizer at a much lower temperature than the water in the boiler, the mean temperature difference between the water and the gases in the economizer is much greater than it would have been in the last half of boiler surface which this economizer replaced. Thus, although the total surface is the same as originally, the gases are leaving this unit, consisting of boiler and economizer, at a much lower temperature, the actual temperature being dependent on the feedwater temperature. This in itself is a considerable financial gain, but when account is also taken of the fact that the Foster surface is much cheaper per square foot than the boiler surface it replaces, the reduction in capital cost is considerable.

In the above example it has been assumed that the economizer should replace 50 per cent of the boiler surface, and that the gases would enter the economizer at 1050 deg. fahr. These figures are purely arbitrary, and each particular case must be studied on its merits.

Installations are now being made where the gases are entering the Foster economizer at 1400 deg. fahr., and other installations where the gases are entering at 100 deg. fahr., and the most economical temperature probably lies somewhere between these two extremes. Further advantages of the Foster steaming economizer are that by its adoption baffles in boilers are eliminated and consequently the unit is more easily cleaned. Another point is that the space taken up per pound of steam generated is much smaller with the steaming economizer and boiler than with the ordinary economizer and boiler. (Part of the Annual Progress Review in *Engineering and Boiler House Review*, vol. 42, no. 7, Jan., 1929. The part of the article abstracted here appears on pp. 348–350 and 353, and includes three figures, of which only one is reproduced, *d*)

Steam-Accumulator Progress

A RUTHS accumulator has been installed in a Lancashire dye works. The original plant consisted of a group of boilers feeding a high-pressure range for driving hydro-extractors and for finishing, the pressure being reduced to feed a low-pressure range for jiggers, kiers, and general heating. Nominally the boiler pressure was 80 lb. per sq. in. and that of the low-pressure range 30 lb. per sq. in. but from a chart before us the boiler pressure varied between 70 and 40 lb. per sq. in., and that of the heating main from 45 to 20 lb. per sq. in. As the result of the installation of the accumulator both pressures were held steady at their proper values and a fuel saving of no less than 39 per cent obtained. This was remarkable in itself, but it was also accompanied by an increase in production amounting in cash value to 21 per cent, the net result being that the total cost per piece was halved.

While the steam accumulator is particularly suitable for plants of the kind referred to, it is rather curious that it was originally provided for taking the peak loads of central power stations, but has not hitherto been adopted to any extent for that service. We have received word, however, that a colossal steam-storage installation is to be erected at the Charlottenburg power station, one of the interconnected stations serving Greater Berlin. The major portion of the base load of the city is carried by the new Klingenberg station which was described in our issue of July, 1927. The load on the station is 40,000 kw. on the average, but during the afternoon it rises to a peak of 80,000 kw. Steam for the additional 40,000 kw. will be provided by the accumulators which, during this period, extending over three hours, will generate 67,000 kw. Sixteen tanks will make up the battery, mounted vertically, each being 14 ft. 9 in. in diameter, 69 ft. high, and of 11,000

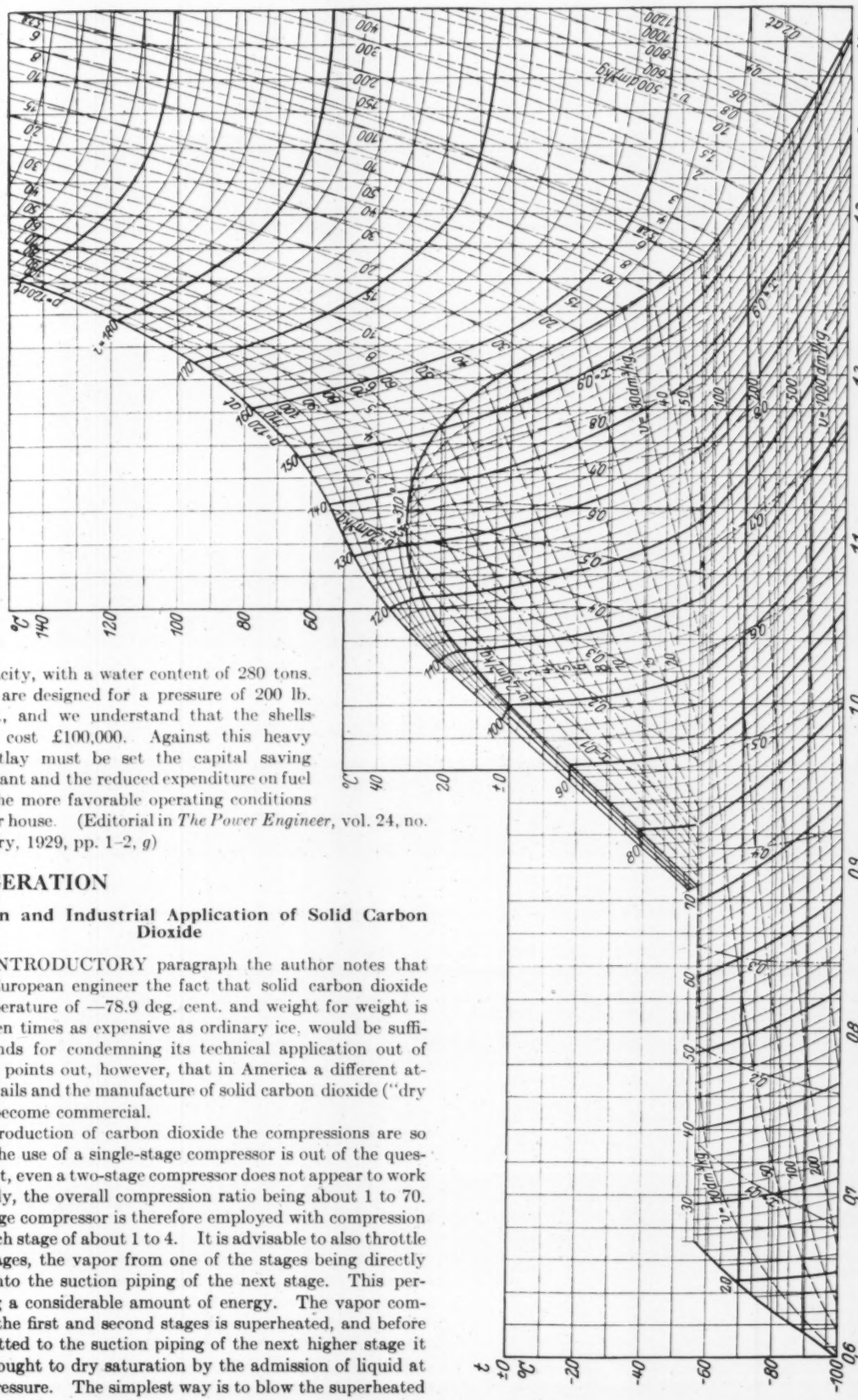


FIG. 4 TEMPERATURE-ENTROPY DIAGRAM FOR ALL THREE STATES OF CARBON DIOXIDE
(For 0 deg. cent. $i' = 100$ kg-cal. per kg.; $s' = 1$ Clausius per kg.)

cu. ft. capacity, with a water content of 280 tons. The tanks are designed for a pressure of 200 lb. per sq. in., and we understand that the shells alone will cost £100,000. Against this heavy capital outlay must be set the capital saving on boiler plant and the reduced expenditure on fuel owing to the more favorable operating conditions in the boiler house. (Editorial in *The Power Engineer*, vol. 24, no. 274, January, 1929, pp. 1–2, *g*)

REFRIGERATION

Production and Industrial Application of Solid Carbon Dioxide

IN AN INTRODUCTORY paragraph the author notes that to the European engineer the fact that solid carbon dioxide has a temperature of —78.9 deg. cent. and weight for weight is about fifteen times as expensive as ordinary ice, would be sufficient grounds for condemning its technical application out of hand. He points out, however, that in America a different attitude prevails and the manufacture of solid carbon dioxide ("dry ice") has become commercial.

In the production of carbon dioxide the compressions are so high that the use of a single-stage compressor is out of the question; in fact, even a two-stage compressor does not appear to work economically, the overall compression ratio being about 1 to 70. A three-stage compressor is therefore employed with compression ratios in each stage of about 1 to 4. It is advisable to also throttle in three stages, the vapor from one of the stages being directly delivered into the suction piping of the next stage. This permits saving a considerable amount of energy. The vapor compressed in the first and second stages is superheated, and before being admitted to the suction piping of the next higher stage it must be brought to dry saturation by the admission of liquid at the same pressure. The simplest way is to blow the superheated

vapor into the intermediate condenser and mix it there with liquid carbon dioxide. In practical operations it is impossible to maintain in all the three stages of compression and throttling the same pressure ratios, as solid carbon dioxide is generated only in the last stage. The pressure head of the last throttling valve and hence the end pressure in the low-pressure cylinder must therefore be at least 6 atmos. abs., and hence the pressure ratio in the lowest stage must be 1 to 6, and in the intermediate and high stages only about 1 to 3.5. The calculation of the apparatus for making solid carbon dioxide can best be carried out on the basis of a heat diagram for the vapor, liquid, and solid states. Such a temperature-entropy diagram plotted with due consideration to the most recent experimental data is given in Fig. 4. The same diagram is available on a larger scale in a paper (in German) by R. Plank and I. Kuprianoff entitled, "Thermal Properties of Carbon Dioxide in the Gaseous, Fluid, and Solid States," in *Zeitschrift für die gesamte Kälte-industrie*, Appendix 1, no. 1, Berlin, 1929. Fig. 5 gives the three-stage process in the form of a temperature-entropy diagram. The condenser pressure is p = 65 atmos., corresponding to a condensation temperature of about t = +25 deg. cent. For the intermediate pressures p_1 = 20 atmos. (t = —20 deg. cent.) and p_2 = 6 atmos. (t_2 = —50 deg. cent.). Assume that 1 kg. of carbon dioxide is circulating in the high-pressure stage and condenser and after leaving the condenser must be cooled to about +15 deg. cent. (point a). Then at the first throttling point p_1 = 20 atmos., an amount of vapor will be

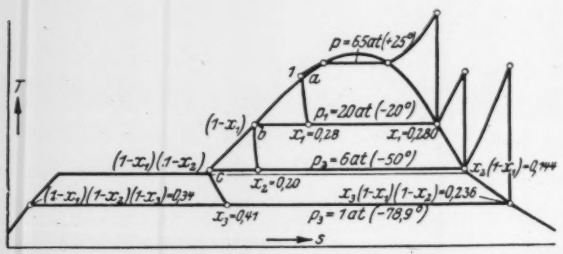


FIG. 5 CYCLIC PROCESS OF PRODUCTION OF SOLID CARBON DIOXIDE BY THREE-STAGE COMPRESSION

generated equal to about x_1 = 0.28 kg., which will be immediately sucked to the high-pressure stage of the condenser, while 1 — x_1 = 0.72 kg. of liquid (point b) will be throttled in the second stage to p_2 = 6 atmos. The mixture thus produced has a specific vapor content of x_2 = 0.20, and consists of $x_2(1 - x_1)$ = 0.144 kg. of vapor which is immediately sucked up by the intermediate-pressure stage of the compressor, and $(1 - x_2)(1 - x_1)$ = 0.576 kg. of liquid (point c).

This liquid carbon dioxide is now throttled in the third stage to p_3 = 1 atmos. and thereby the temperature is lowered to —78.9 deg. cent. and a mixture is produced consisting of x_3 = 0.41 part vapor and 1 — x_3 = 0.59 part snow. The same expressed in parts by weight is $x_3(1 - x_2)(1 - x_1)$ = 0.236 kg. of vapor and $(1 - x_3)(1 - x_2)(1 - x_1)$ = 0.340 kg. of snow. At this stage the low-pressure cylinder of the compressor takes up by suction this vapor, which, as stated above, weighs 0.236 kg., and in addition must be freshly supplied with the same weight of carbon dioxide gas that has been taken out of the cycle in the form of snow, or 0.340 kg.

It would appear, therefore, that from every kilogram of carbon dioxide liquefied in the condenser, 0.34 kg. or 34 per cent of snow is obtained. The very cold vapor produced in the last stage of throttling can be used for further intercooling of the liquefied carbon dioxide before admitting it to the low-pressure stage of the compressor. If this is done, point a is shifted further to the left and the output of solid carbon dioxide is somewhat increased; simultaneously with this, however, the energy consumption of the low-pressure stage of the condenser is increased. It is also possible to utilize the vapor having a temperature of —50 deg. cent. from the second throttling state for cooling the liquid carbon dioxide. In this way the output of solid carbon dioxide can be raised to about 40 per cent of the weight of the liquid contained in the condenser.

The author discusses next the properties and advantages of solid carbon dioxide as a refrigerating medium. This part is of comparatively minor interest as it is practically exclusively based on British and American practice. (R. Plank in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 7, Feb. 16, 1929, pp. 221–224, 2 figs., *tp*)

RESEARCH

New Fuel-Research Laboratory in Canada

THE Department of Mines has erected in Ottawa a new fuel-research laboratory building. The equipment was selected with a view to carrying out investigations which would be of interest in the development of coal resources of the Dominion. In addition to the usual equipment there will be provided a by-product-recovery coke plant which will have a capacity of 2 tons and will be of a type which is now being used commercially in the United States, particularly in Illinois. This oven will be complete with gas condensing, scrubbing, and recovery train, and will enable the coking properties of coals to be determined in great detail. A Koppers small-scale carbonization apparatus will be available to carbonize small representative samples before coking the coals. An experimental domestic heating plant will also be provided and the investigations will be extended to include fuel oil, retort gas, producer gas, and coals in their natural state. A complete commercial powdered-fuel steam-generating plant will be also available, with provision for changing burners, etc., to suit particular fuels.

There will be also provided a commercial-scale briquetting plant which will be equipped with two types of presses—roll and plunger—and such equipment as crushers, fluxors, macerators, etc.

As regards low-temperature carbonization, the permanent equipment to be installed will consist of only one or two technical-scale retorts constructed on two of the main systems—for example, internally and externally heated. It is proposed, however, as the occasion arises, to erect technical-scale low-temperature carbonization retorts of different types with a capacity of from 500 to 1000 lb. of fuel. There will be also available an oil-cracking and refining plant, as well as oil-shale retorts and a large-scale coal-washing plant. (*Contract Record and Engineering Review*, vol. 42, no. 48, Nov. 28, 1928, pp. 1237–1239, 2 figs., *p*)

SAFETY ENGINEERING (See Marine Engineering: German Precautions Against Explosions on Diesel-Engined Vessels)

SPECIAL MACHINERY

Progress in Drop-Forge Equipment

FROM a review of the drop-forging industry for the year 1928 it would appear that the business has been prosperous and that some interesting technical developments have been made.

An important change in anvil design is the elimination of all cored openings in the anvil, the holes for housing-bolt nuts being machined from the solid. This is expected to increase greatly the resistance of the anvil block to breakage. Evidence continues to accumulate that, in anvil design, the weight is placed to the

greatest advantage when it is directly under the blow, and that the strength of the anvil and its useful life increase with an increased depth of the metal section directly below the sow block.

In the case of trimming presses, there seems to be a tendency toward the shrink-bolt frame construction in smaller sizes than it was previously used in. Lubrication problems are having more attention throughout the shop; but whereas the use of modern lubrication systems, with all bearings oiled from a central point, is made difficult on board drop hammers because of the severe conditions of shock, and is still in the experimental stage, the conditions with trimming presses are much easier, and many presses are being fitted with systems of this type. It is predicted that in the next few years more complicated types of trimming dies will be generally used, possibly combining the trimming, punching, and restriking of the forging in one stroke of the press, thus increasing production by not taking the time of the hammer for restriking. Operations such as the padding of axles, including not only the flattening of the top of the pad, but also the forming of the recesses on the bottom of the heads of the bolts, are now being performed in special presses having a horizontally sliding gripping ram in addition to the main ram. Some forge men believe that presses of this type can be used to advantage for light upset work, of such a nature that it can be handled better in the press due to its vertical arrangement. (MacDonald S. Reed (Mem. A.S.M.E.), Erie Foundry Co., in *Heat Treating and Forging*, vol. 15, no. 1, January, 1929, pp. 42–43, 1 fig., *gd*)

SPECIAL PROCESSES

A Study of Metal-Mold Centrifugally Cast Pipe vs. Sand-Cast Pipe

THE object of this investigation was to determine the relative merits of sand-cast pipe and pipes centrifugally cast in metal molds. The matter of corrosion was not investigated. The investigation was undertaken at the request of the Water Board of the City of Detroit, and was made on 48 pieces of pipe. The report covers findings on twelve properties of pipe.

The following is of particular interest. Metal-mold centrifugally cast pipe is annealed after casting, and this is supposed to free it from all casting strains. In this connection the report states that—

> It should be borne in mind that it is the annealing and not the casting process that does away with cooling strains and, that if not carefully done the strains are apt to be worse in centrifugally cast pipe than in sand-cast pipe. It should also be borne in mind that in the first four samples of pipe submitted, there was one cracked centrifugally cast pipe which was not discovered until put into the milling machine for cutting specimens. The crack had evidently been in the pipe before it was dipped, for the solution had penetrated into the crack slightly. The crack could have been a pure shrinkage crack or impact crack, or, what is more probable, a combination of the two. So the practice, if thoroughly carried out, should favor the centrifugally cast pipe, but the fact remains that the only specimen of those submitted in this test which displayed evidence of a cooling strain was a centrifugally cast pipe.

The centrifugally cast pipe is on the whole smoother on the inside than pit-cast pipe. Transverse tests favor the sand-cast pipe from the standpoint of resistance to transverse loads and centrifugally cast pipe from the standpoint of deflection before breaking. Centrifugally cast pipe is slightly harder than sand-cast pipe. The higher hardness is not objectionable from the point of view of machining, but contributes to the objectionable brittleness qualities of any cast-iron pipe and checks the inferior impact values of centrifugally cast pipe. Centrifugally cast pipe shows a lower combined carbon content, which would indicate easier cutting qualities of the pipe.

Under "Conclusions" twelve tests—five primary and seven secondary—are listed. Of the primary, two tests—tension and variation in thickness—favor centrifugal pipe, two tests—impact and radial compression—favor sand-cast pipe, and on one—removal of strain—there is no decision. The conclusions are that with present practice and on the basis of similar costs there is no outstanding advantage to either kind, but on the basis of lower costs for centrifugally cast pipe, that pipe is favored. (F. N. Menefee and A. E. White (Mem. A.S.M.E.) in *Publication of Department of Engineering Research, Univ. of Michigan, Ann Arbor, Mich., Reprint Series No. 4*, Aug., 1928. Reprinted from the Proceedings of The American Society for Testing Materials, vol. 28, part II, 1928; pp. 1–31, 30 figs., and discussion on pp. 32–37, *ce*)

STEAM ENGINEERING

Influence of Water Globules in Steam on Turbine Performance

THE presence of water globules or droplets in steam may affect turbine performance unfavorably in several ways. Wet steam reduces the turbine efficiency: (1) by producing undercooling, (2) by increasing friction, and (3) by the breaking action of the water particles themselves. In a multi-stage turbine complete undercooling does not occur, and partial undercooling, while possible, is of minor importance. On the other hand, the formation of water droplets, which at times are of considerable size, has to be considered. At the instant of separation of the water no loss of energy occurs as the total mass of working fluid remains unchanged, and the droplets of water in the first instant retain the velocity of the steam. At a later period, however, the presence of these droplets is found to interfere considerably with the flow of steam.

From this the author proceeds to a derivation of equations showing the loss of energy due to formation of water droplets. This loss of energy may be materially reduced by removing the water from the working spaces, which is not easy, however, from a mechanical standpoint. A more effective method is interstage superheating, which simultaneously improves materially the thermal efficiency of the turbine process. Thus, if the initial pressure of the steam is 50 atmos., the initial temperature 400 deg. cent., and the end pressure 0.05 atmos., then the thermal efficiency for the Clausius-Rankine process is 0.381. If, however, superheating is introduced with isothermal expansion at 400 deg. cent. in such a way that the succeeding adiabatic expansion at the end is exactly that required to produce dry saturated steam, an efficiency of 0.427 is obtained. For the ideal case of infinitely multi-stage initial preheating working on the above process, an efficiency of 0.469 is obtained, and this is the highest possible thermal efficiency which can be obtained within the pressure limits specified above, and with the above assumed initial temperature of the steam.

The quality factor of a steam turbine working with interstage superheating is determined by the ratio of energy obtained to energy available. If p_1 and t_1 denote the pressure and temperature of the steam at admission, p_2 and t_2 the final values of pressure and temperature at saturation, H_0 the adiabatic heat drop between p_1, t_1, and p_2, ΣQ_u the total heat of interstage superheat, and $\Sigma \Delta s_u$ the total increase in entropy produced thereby, then the available work will be

$$AL_0 = H_0 + \Sigma Q_u - T_2 \Sigma \Delta s_u$$

Emphasis is laid on the importance of determining the viscosity of steam at high pressures. (G. Zerkowitz, Munich, in a paper before the meeting of the Committee on Heat Research, Dec. 1, 1928. Abstracted through a report by Max Jakob in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 3, Jan. 19, 1929, p. 84, *t*)

TESTING AND MEASUREMENTS

Determination of the Heating Value of Gas Coals by the Geipert Method

THIS method was brought out about two years ago and is said to be precise and convenient to operate. In this method a vertical quartz retort is used which is heated to a temperature of exactly 1100 deg. cent. in an oven well insulated against loss of heat by radiation. The process is repeated three times with 10 grams (154.3 grains) of coal compressed into small tablets. After filtering out the tar through spun glass or absorbent cotton, the gas produced in each of the three operations is collected in measuring pipettes immersed in water, and the heating value of the gas is determined by means of a Junkers calorimeter after the gas has been transferred to a measuring bottle of 12 liters (3.17 gal.) content. The volume of gas produced and its heating value are determined by the degree of decomposition of the tar and the hydrocarbons in the gas, and this latter depends materially on the temperature of the gasification chamber, the path which the raw gas has to travel in this superheating chamber, and the rapidity of generation of the gas. Geipert succeeded in determining the mutual influence of these factors so closely that they correspond exactly to the conditions prevailing in the operation of gas generation.

Furthermore, the absolute maintenance of the experimental factors set forth by Geipert is in any event a condition without which the production of uniform and correct results is impossible.

The Dessau Vertical Retort Co. has presented to the German Gas Institute a set of the Geipert apparatus, and a large number of tests have been carried out with it with the idea of proving the usefulness of the Geipert process.

The authors claim that this has been done and indicate certain conditions which should be satisfied and methods of operation to insure correct results; among these they specify that the temperature of the entire quartz tube should be uniform and that the location of the flame element connection should be exactly at a certain point. It is said that in the gasification of tar coal the values obtained by the Geipert apparatus correspond well with those obtained in actual practice. When, however, washed small gas or coke coal was used with a moisture content of up to 10 per cent, the figures obtained by the Geipert process did not agree so well. (K. Bunte and W. Zweig in *Das Gas und Wasserfach*, vol. 71, no. 26, June 30, 1928, pp. 629–631, *e*)

THERMODYNAMICS (See also Refrigeration: Production and Industrial Application of Solid Carbon Dioxide)

Steam Formation and Vaporization

A NUMBER of papers on thermodynamic processes were presented at a meeting of the Committee on Heat Research held in Dresden, December 1, 1928.

Among others, E. Schmidt, of Danzig, contributed a paper in which he questioned the present theories of water circulation in boilers. He claimed that relative velocity of bubbles of steam with respect to water must not be neglected and that in a rising column of water at saturation temperature, even without any further admission of heat, there will be a certain amount of auto-vaporization, because of the decrease of pressure from the bottom to the top of the column, and this auto-vaporization will in the majority of cases considerably exceed the evaporation at the pipe wall. He indicated further that the auto-vaporization may explain the often-observed reversal of circulation in tube bundles. As a result of this reversal the liquid in strongly heated tubes sinks and in tubes slightly heated or not heated at all, rises. Schmidt's new theory of water circulation is derived from a differential equation for the density of a steam and water mixture as a function of the height of the tube for a given amount of circulation. For a given load on the heating area it becomes possible to derive from these equations the velocity of circulation in a tube, provided the relative velocity of steam bubbles with respect to the water is known. Tests were made with an open tube, where the water was evaporated by admitting heat from below, new water being next supplied from below also. It was found that the relative velocity depends on the diameter of the tube, increases with an increasing content of steam in the mixture, and under practical conditions is somewhere between one and two meters per second.

Herr Fischer of Dresden reported on his evaporation tests. He passed air of varying moisture content over a still water surface, permitting the air to take up moisture from the latter. The main difficulties which are yet to be overcome consist in the determination of the temperature of the water surface. Hitherto only the average temperature of the water could be measured. Another difficulty lay in the formation of large waves when the velocity of the air was from 4 to 6 m. per sec. In the course of the tests the velocity and temperature of the air (up to 120 deg. cent.) and the moisture content were varied. Let W designate the amount of water evaporated in a unit of time from a unit of area; $x' = 0.622\ h'/(H - h')$ the water content of saturated air at a given water temperature, and $x = 0.622\ h/(H - h)$ the moisture content in the air, where H is the barometric pressure, h' the saturation pressure, and h the partial pressure of the water vapor. Then the coefficient of heat transmission can be expressed according to Merkel by $\sigma = W/(x' - x)$, which the author calls the "coefficient of water transmission." With this coefficient it becomes possible to get dimensionless expressions for both evaporation and heat transmission, as well as to obtain specific functions such as potential laws by applying the principle of similarity. This makes it possible to define clearly the influence of water-surface characteristics, as with the appearance of even the first small waves the exponent in the potential expression suddenly increases, which is similar to what occurs in flow processes at the instant when laminar flow passes into turbulent flow. (Max Jakob, Berlin, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 3, Jan. 19, 1929, pp. 83–84, *t*)

The Thermodynamic Diagram of the Rochefort System

THE characteristic of this system is that it combines in the formation of the combustible mixture thermal atomization with mechanical atomization. In the former, by means of a proper supply of heat a rich emulsion is formed which is then diluted with air. The mechanical atomization requires merely that the liquid fuel be finely divided by means of compressed air or by means of a very high pressure applied to the liquid itself. The combination of these two processes is said to make it possible to attain better results at a lower cost than otherwise, to avoid the use of high pressures which are required when only mechanical atomization is used, and in consequence to obtain a more economical engine construction. The system employs the gas content of the cylinder, or the active gas, the combustion of which liberates the energy utilized in the motor, as well as an auxiliary reserve of carbureted gas which serves as a vehicle for the energy necessary for the atomization of the fuel. The following analysis of the cycle and theoretical diagrams of an engine operating on the Rochefort system will give a clearer insight into the mechanism of these processes. The authors start (for the sake of fixing the ideas) with the theoretical diagram of the classical explosion cycle drawn on the assumption of adiabatic compression and expansion, but substituting for the combustion

and exhaust, exchanges of heat at constant volume. The conclusions thus obtained furnish at least some qualitative indications of what actually takes place.

Referring to Fig. 6, the diagram *AMEFG* is at once a mechanical diagram of the work exerted on the piston and a thermodynamic diagram of the evolution of the fluid constituting the cylinder mixture.

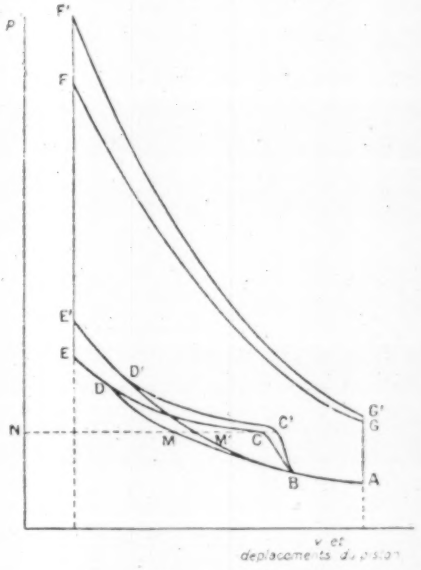


FIG. 6 THERMODYNAMIC DIAGRAM OF THE ROCHEFORT SYSTEM

In the Rochefort system the mechanical diagram is modified by the injection, which temporarily raises the pressures during the period of presence of auxiliary gas in the cylinder, with the result that instead of the arc *BMD* there are two successive arcs *BC* which correspond to the injection and *CD* which express the discharge. The mechanical diagram *ABCDEFG* is therefore no longer a diagram of thermodynamic evolution, as the gas quantity in the cylinder varies. Since, however, the quantities which enter and leave are the same, it is possible to segregate mentally the auxiliary gas by assuming that it operates like a second piston, instantaneously reducing the volume of the active gas.

One may consider first the hypothesis that there is no exchange of heat between the two quantities of gas. The behavior of the active gas is then adiabatic, i.e., it conforms to the diagram *AMEFG*. A cylinder full of active gas delivers then the same total work, represented by the area of the diagram, and the missing work on the piston is exerted directly on the atomization gas, and is equal to the area *BCDMB*. The quantities of auxiliary gas and of gas filling the cylinder are, for the position of the piston corresponding to the point *C*, proportional to *MC* and *NM*. This hypothesis of adiabatic behavior would demand that the energy corresponding to this work be given up by the auxiliary gas to the walls of the chamber in the form of heat. As a matter of fact this is not so, and a part of the work *T* exerted on the atomization gas may be recovered by making adiabatic the walls of the "recovery collector." In practice they are maintained at a temperature approximately equal to that prevailing at the end of the compression, by means of a double jacket through which the exhaust gas circulates. Under these conditions the energy corresponding to work *T* will then be delivered by the auxiliary gas to the active gas in the form of heat. The mechanism of this is simple: The work *T* is first transformed into heat during the period of discharge with compression, and is then given up to the cylinderful of gas in accordance with the kinetic energy of the atomizer, which latter energy is converted back into heat. The transmission of heat to the active gas takes place instantly, because of the intimate mixture of the two gases.

In the thermodynamic diagram of the active gas the arc of the adiabatic is replaced by *BN'E'*, from which it follows that the point of maximum pressure on the diagram is shifted from *F* to *F'*, and the adiabatic *FG* is replaced by the adiabatic *F'G'*. The cycle representing the work exerted on the auxiliary gas is consequently changed from *BCDM* to *BC'D'M'B*, and the following relation holds good:

$$\frac{M'C'}{NM'} = \frac{MC}{NM} = K$$

The area *BC'D'M'B* measures indifferently the work *T* or the equivalent heat *Q* surrendered to the active gas along the line *BM'E'*. It is in the supplementary part *G'G* that the heat *q* is evolved, and this measures the energy really spent in atomization. It is easy to see that *q* is smaller than *Q*. To prove this let *S* be the heat which corresponds either to *EE'* or *FF'*. The areas *BMEE'MB* and *GFF'G'G* are then respectively equal to *S*—*Q* and *S*—*q*, and hence *Q*—*q* = area *GFF'G'* minus area *BEE'*. If the corrections due to the variations in specific heat be neglected it will be found that *EE'* = *FF'*, and as the triangular lower area is manifestly smaller than the quadrangular upper area, *Q* — *q* is greater than zero, whence it follows that *q* is smaller than *Q*. (J. Auclair and J. Villey in *Comptes Rendus des Seances de l'Academie des Sciences*, vol. 187, no. 17, Oct. 22, 1928, pp. 699–701, 1 fig., *t*)

The Radiation and Convection of Heat

THE author deals with the general subject and reports certain experiments. These experiments of his have shown that the amount of heat lost from a surface at a given temperature excess over its surroundings depends not only on the area of surface exposed and on its temperature, but also on the shape and disposition of the surface.

In one series of experiments loss of heat by natural convection and by radiation from a heated wire in air was determined, and in another series steam was passed through a hollow copper cylinder or sphere and the total heat lost from the surface was obtained from the mass of steam condensed; this was measured for two cases: when the surface was bright, and when it was covered with a dead-black varnish. Certain rather surprising results were obtained. In the first place the total heat (radiation + convection) *per square centimeter*, was found to decrease very considerably as the diameter of the tube was increased (from $^1/_2$ in. to 2 in.). If the diameter was increased fourfold the loss of heat per unit area by *convection alone* was approximately halved; and, generally, the heat lost per unit area was inversely proportional to the square root of the diameter of the tube. The product of convection (excluding radiation) and the square root of the diameter was found to be approximately constant.

The loss of heat by radiation alone, especially in wires and narrow tubes, was found to be only a small proportion of the total heat loss, especially with the unblacked surfaces. The great increase in total loss of heat per square centimeter in the narrower tube appears to be entirely due to convection, i.e., radiation per unit area is the same whatever the curvature. This applies, however, only to surfaces heated in still air. Conditions are different when a current of air is blown past a surface at moderate temperatures.

Drs. Ezar Griffiths and A. H. Davis, in a special report to the

Food Investigation Board, observe that a very marked decrease of radiation from one surface to another is caused by placing parallel partitions between the hot and the cold surfaces. For example, if a partition is placed halfway between the surfaces its temperature will be approximately intermediate between those of the two surfaces, thus reducing the radiation to one-half. Two

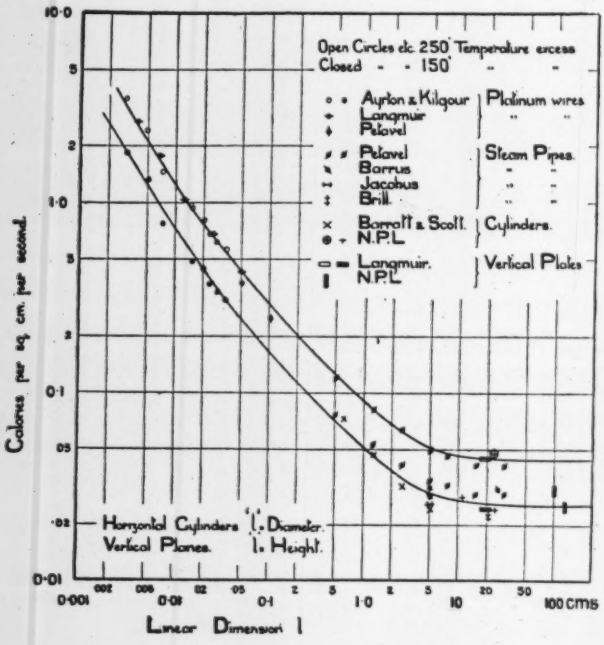


FIG. 7 EFFECT OF SIZE AND CURVATURE ON HEAT LOSS BY CONVECTION

such surfaces will reduce it to one-third, and so on. This explains why the minute subdivision in such a substance as cotton wool and certain thermal insulators will reduce the radiation practically to zero.

An interesting diagram from the same report is given in Fig. 7, which illustrates the effect of size and curvature of the surface on the heat losses by convection, and greatly extends the results of experiments by the author which are discussed above.

An interesting point illustrated by the diagram is that the convection loss per unit area for small diameters decreases quickly as the diameter increases, but that for diameters of about five centimeters (2 in.) and upward the loss per unit area is nearly constant.

The following practical applications of the foregoing are suggested:

The laws of radiation of heat (which are the same as the laws of absorption of heat) indicate that owing to the operation of the fourth-power law, the amount of heat absorbed by a surface rises very rapidly as the temperature of the radiating body increases. For example, the heat received by a surface—say, the water tube of a boiler—at 300 deg. fahr. is more than doubled if the temperature of the furnace is increased from 2000 deg. to 2400 deg. fahr. abs.

The laws of convection of heat, applying equally well to the heat transferred from the hot gases to the tube or boiler surface, and from the tubes to the water inside them, show that for a rise of temperature of the furnace gases from 2000 to 2400 deg. fahr. abs., the increase in the heat given to the boiler tube by convection is relatively small, i.e., only about $1^1/_4$ times, even under the most favorable conditions.

There is an inert film of gas on the furnace side of the boiler tube which is untouched by convection currents, but which can be pierced by the radiation. This film may be $^1/_{80}$ in. in thickness, though doubtless this varies with the temperature and with the speed of movement of the furnace gases. It has been estimated that 95 to 98 per cent of the convected heat is lost in forcing its way by conduction through this film of gas, and largely owing to this fact the outside of the tube is usually only 50 to 100 deg. hotter than the inside.

There is also a "dead water film" in the inside of the tube, whose influence on the transfer of heat from the tube to the water depends on the velocity of movement of the latter. It is probable that 2 or 3 per cent of the heat received by the tube, both by radiation and convection, is lost in forcing its way past this water film.

The resistance offered to the passage of heat by the metal of the tube itself is thus only about 1 per cent of the total resistance, and consequently very little improvement can be effected by using a metal of higher conductivity, say, copper instead of iron, although its conducting power is six or seven times as great. Matters are not improved, of course, if a "scale" of iron oxide is allowed to form on the outside of the tube, or a deposit of any kind on the inside. Not only have these deposits a much lower thermal conductivity than the iron, but they will tend to imprison thicker inert layers of gas or liquid.

Thermal conductivities of the substances in question are approximately as follows (stated in c.g.s. units): Copper, 0.93; iron, 0.15; iron oxide, 0.001 to 0.003; water, 0.0013; air, 0.000055.

It is not very difficult, in view of these considerations, to understand the superiority from the point of view of efficiency of tube boilers over other types. A water-tube boiler can offer a relatively much larger surface to direct radiation from the furnace, while even the multi-tubular (fire-tube) boiler depends to a very large extent on convection. Another advantage with the best type of tube boiler is that the circulation of water is systematic and rapid, thus tending to remove or reduce in thickness the inert film of water inside the tube. In a boiler of the Cornish or Lancashire type, on the other hand, the circulation of water is more or less casual.

The author therefore suggests the following:

1 An increase in the area of the tubes exposed to direct radiation. This may perhaps be effected by a "bird-cage" kind of construction (the term was suggested to the author by Mr. L. Marshall Jockel, M. I. E. S.), the tubes being arranged at a steep angle around the furnace and converging toward a point above. It is realized that this might involve difficulties in systematic circulation, but these might not be insuperable.

2 The employment of still higher furnace temperatures.

3 Increased speed of the furnace gases outside the tubes, and of the fluid content (water and steam) inside them, in order to neutralize the effect of the "dead" films of gas and water. Rapid circulation of the water inside the tubes would also have the effect of preventing to a large extent the formation of a deposit therein. (T. Barratt, D.Sc., in a paper read before the Institution of Fuel Economy Engineers, London, December 3, 1926, and published in the *Journal of the Institute of Fuel*, vol. 1, no. 4, July, 1928, pp. 396–401, together with discussion on pp. 401–403, 3 figs., *e*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Instruments and Apparatus

Preliminary Draft of Part 13—Speed Measurement

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment, Part 13—"Speed Measurement," of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and J. T. Ward.

The Instruments and Apparatus Section will consist of twenty-two parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (12 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Materials, (6) Electrical Measurements,[4] (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition (5 chapters), (11) Determination of Quality of Steam, (12) Time Measurements, (13) Speed Measurement, (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Determination of Viscosity of Liquids, (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke, (21) Leakage Measurements (2 chapters),[5] and (22) Hydraulic Power Plants.

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

TABLE OF CONTENTS OF COMPLETE DRAFT

	Par.
General Description and Classification	1
General Precautions in Taking Readings	6
General Remarks with Respect to Calibration	10
I—Counter and Timepiece Method	20
Continuous Counters	22
Range and Accuracy	29
Installation	34
Precautions in Taking Readings	35
Hand Counters	37
Range and Accuracy	39
Installation	41
Precautions in Taking Readings	43
Hand Counter and Stop Watch	45
Tachoscope	46
Speed Indicator	51
II—Tachometers	57
Tachometer Drives	59
Centrifugal Tachometers	60
(*a*) Flyball and Tilting-Ring	61
(*b*) Centrifugal Liquid Pump	66
(*c*) Air Tachometer	69
Autographic Hydraulic Pump Tachometer	74
Volume Pumpage Tachometer	78
Force-Drag Tachometer	81
Chronometric Tachometer	85
Electric Tachometers	90
(*a*) Electromagnetic Type	91
(*b*) Frequency-Meter Type	93
Vibration Tachometer	100
III—Stroboscope	102

[1] This part was published in the February, 1923, issue of MECHANICAL ENGINEERING.

[2] Chapter 1 of Part 2, on Barometers, was published in the November, 1927, issue of MECHANICAL ENGINEERING

Chapter 6 of Part 2, on Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements, was published in the July, 1928, issue of MECHANICAL ENGINEERING.

[3] Chapter 1 of Part 3, General, was published in the December, 1925, issue of MECHANICAL ENGINEERING.

Chapter 6 of Part 3, on Glass Thermometers, was published in the April and May, 1926, issues of MECHANICAL ENGINEERING.

Chapter 7 of Part 3, on Pressure-Gage Thermometers, was published in the October, 1928, issue of MECHANICAL ENGINEERING.

[4] This part was published in the December, 1928, issue of MECHANICAL ENGINEERING.

[5] Chapter 1 of Part 21, on Condenser Leakage Tests, was published in the November, 1925, issue of MECHANICAL ENGINEERING.

GENERAL DESCRIPTION AND CLASSIFICATION

1 Speed is defined as the time rate of motion. The measurement of two forms of speed is considered in this section:

Angular Speed, usually determined in revolutions per minute (r.p.m.); and

Linear Speed, usually determined in feet per minute (ft. per min.).

2 There are three general methods for obtaining the angular speed of rotating machinery: first, by means of a revolution counter and a timepiece; second, by the use of a tachometer; and third, with a stroboscope.

3 Linear speed is calculable from angular speed when the two are associated. For example, the linear speed of a locomotive could be deduced from the angular speed of its wheels. Some tachometers indicate both angular and linear speeds.

4 Measurement of the speed of flow of fluids is treated in Part 5 on "Measurement of Quantity of Materials."

5 In measuring the speed of slow-moving machinery, such as stoker ram shafts, etc., it is necessary to time only one or a few revolutions and record the result in seconds per revolution or per stroke. This then may be converted to revolutions (or strokes) per minute. Care should be used in tests on slow-moving machinery to include exactly one or more complete revolutions, as a small fraction of a revolution in slow rotation may introduce a large percentage error when calculated to revolutions per minute. It is best to use a rotating part for reference rather than to note the time from the end of a stroke of a reciprocating member, since the exact end of the stroke is often difficult to determine.

GENERAL PRECAUTIONS IN TAKING READINGS

6 When measuring speeds of 600 r.p.m. or more, a positive drive (see Par. 59) between the revolving shaft under observation and the speed-measuring instrument should be employed. The slippage of any contact device, such as a sharp-pointed or rubber-tipped instrument shaft, introduces an error of unknown magnitude.

7 When the drive is secured by an adapter on the tachometer shaft pressed in contact with the center of the rotating shaft, the axis of the tachometer shaft must be in line with the axis of the rotating shaft. In using this type of drive in connection with light machinery, particular care must be taken, as the end thrust due to pressing the tachometer shaft into the shaft center may reduce the speed materially.

8 When using a flexible-shaft drive ample time should be allowed for the shaft to wind up before taking a reading of the speed-measuring instrument. The instrument should not be

read during the period that the flexible shaft is retarding due to slowing down of the revolving shaft under observation, or due to the disconnecting of the flexible shaft. At low rotative speeds and for short periods of observation, errors of considerable magnitude will occur if these precautions are not observed.

9 In taking linear speeds, be certain that sufficient pressure is exerted to prevent the rubber friction disk from expanding under centrifugal force sufficiently to produce an error due to changing the effective radius of the disk.

General Remarks With Respect to Calibration

10 Calibration is necessary in order to determine the instrument errors and thus be able to make the proper corrections. If the calibration is made near the operating temperature and close to the time of making the test, the errors due to temperature and changes with time can be largely obviated. Uncertainty in the knowledge of the actual speed is thus reduced to a minimum.

11 A tachometer can be calibrated by driving it from an electric motor running at a constant controllable speed which is measured by a gear-train counter and stop watch. If a gear-train counter is not available a hand revolution counter can be used if it is driven from the motor in a positive manner, such as by using gears, chains, or speed pins which are described in Par. 59.

12 The driving motor should have sufficient inertia so that its speed is undisturbed when the tachometer being calibrated is placed in contact or removed from the end of the shaft, if it is used and calibrated under such method of contact.

13 The stop watch to be used in the calibration should be previously calibrated against a pendulum-operated standard clock for several intervals of time of the same duration as those to be used in the calibration. Electric clocks controlled by a master clock are not suitable for such stop-watch calibrations, as a very slight variation in the frequency of the motive current will cause an error in the clock sufficient to be measured by a stop watch. (See Part 12 for further discussion of time measurements and calibrations.)

14 The interval of time chosen for counting the number of revolutions of the tachometer should be at least two minutes, and preferably longer. Readings of less than one minute should never be considered when accurate results are desired. All personal or stop-watch errors introduced in the starting and stopping of the stop watch are multiplied when fractional-minute readings are taken, and will greatly magnify the error when reduced to r.p.m. In readings longer than one minute, such errors are minimized. The greater the number of minutes, the more negligible such errors become.

15 In making calibrations it is usually more convenient and more accurate to measure with a stop watch the time required for a given number of revolutions of the tachometer than it is to try to count the revolutions in a given period of time.

16 When the calibration is in progress great care must be taken in starting the stop watch to see that such starting occurs at the instant when the fastest-moving hand of the gear-train counter passes the zero mark. The same precaution is to be observed in stopping the watch.

17 At last two readings should be taken for each speed at which the tachometer is calibrated.

18 For speeds above the range of ordinary counters, a gear reduction should be used. The gears must make a positive drive between the rotating member, the speed of which is to be determined, and the counter.

19 In the calibration of tachometers, while the tachometer may be driven in a manner in accordance with the conditions of use, the standard or reference counter must be driven by one of the three positive-drive methods given in Par. 59.

I—Counter and Timepiece Method

20 A counter is an instrument for determining the number of revolutions or strokes of a rotating or reciprocating mechanism. It is constructed so that a primary driving device of the instrument is moved by direct contact with the moving object. It registers continuously from time of engagement until disengagement.

21 Counters are classified as continuous and hand instruments. Continuous counters are used where a determination is sought over a considerable extent of time, while hand counters are used for determining the number of revolutions over a short period of time. They are further classified according to the form of primary driving device employed.

22 In general, continuous counters are used on tests of displacement machinery such as pumps, stokers, etc., when great accuracy is desired in the measurement of the total volume displacement or average speed. There are three types of continuous counters: the direct-geared, the cyclometer, and the flat ratchet types.

II—Tachometers

57 A tachometer is an instrument for indicating speed directly and continuously. Table 1 [not reproduced here] gives a brief description of the operating principles of various types of tachometers or speed-measuring devices. The factors which affect their accuracy are also given. These latter are divided into "operating conditions" and "changes in the tachometer mechanism."

58 It is best to refer to the accuracy of a tachometer in terms of r.p.m. instead of percentage, as it has substantially a constant r.p.m. error over the upper 70 to 80 per cent of the working range. Most tachometers read from 0 to about 2500 or 0 to 1200, and in most types the reading should be in the upper 75 per cent of the range and preferably in the upper 50 per cent. The driving-gear ratio can, of course, be changed to meet any actual range of speed.

59 Tachometer drive can be obtained by any one of the five methods, given below. Whenever possible one of the first three should be used.

(*a*) Gear or chain. This is a positive drive.

(*b*) Flexible shaft or cable enclosed in a flexible housing. This is a positive drive.

(*c*) Speed pin threaded into the end of the revolving shaft under observation with a metal sleeve slotted in both ends for a driving link between the shaft and the tachometer. This is a positive drive. Care must be taken to align the tachometer and the revolving shaft properly.

(*d*) Adapter on tachometer shaft pressed into contact with a so-called "center" on the rotating shaft of apparatus being tested. Care must be taken to avoid slipping, also to insure that the axis of the tachometer shaft is in line with the axis of the rotating shaft, thereby avoiding eccentricity.

(*e*) Belt and friction drive. The use of this method should be avoided as it is unreliable, and any one of the four preceding ones employed.

III—Stroboscope

102 The stroboscopic method of measuring rotative speed utilizes the persistence of vision when an object is viewed intermittently. This method can be used successfully in determining the revolutions of light-powered machinery where the load to drive another type of a revolution-measuring instrument would materially reduce the speed.

Engineering and Industrial Standardization

Industrial Standardization Pays

INDUSTRIAL STANDARDIZATION has been a paramount factor in the recent economic progress of the United States, and "cumulative evidence points unmistakably to the conclusion that it is one of the most significant and far-reaching methods for increasing industrial efficiency to the benefit, if properly used, of all interests concerned."

"Tangible and trustworthy facts regarding the achievements and economies of standardization," however, "are few and far between," and "it is clear that the achievements in the past are but guide posts to possibilities in the future."

Such, in brief, is the summing up by the National Industrial Conference Board, 247 Park Avenue, New York, of its findings of a study of the industrial-standardization movement and its effects upon economic life. However, although the Board thus indicates certain reservations in evaluating the ultimate economic effects of standardization, it nevertheless is inclined to attribute great potential value to the effects of standardization upon social and cultural progress, provided the evidence found in support of the net economic benefits of the movement should prove conclusive. Quite contrary to the popular impression in many quarters that standardized consumer's goods and standardization in industrial and commercial methods tend to develop stereotyped living conditions and habits, the Board declares that "if the machine (through standardization and mass production) is able to democratize leisure, it may be opening up the way for the greatest cultural renaissance in the history of the world."

Standardization, the report points out, means many things besides the mere standardizing of product as to size, quality, design, or of methods and procedure in the productive process proper. It is applied in increasing degree to the functions of business procedure in all its branches, as in purchasing specifications, in distribution methods, transporting and handling, clerical work, finance, and communication, always with the immediate aim of economizing material, effort, and time. "So pervasive is the application of the principle that. . . we have failed to appreciate its significance, the extent and manner by which it is being systematically advanced, its relation to industry, to government, and to the public, and the problems to which it has given rise."

Standardization should be regarded as a tool, a method, a device, or a technique for achieving certain ends. Whether or not advantages outweigh disadvantages is found to depend entirely upon what use is made of standardization, as it may retard as well as promote industrial progress. In practice, judgment as to particular standardization projects or as to standardization in general must rest upon a satisfactory answer to the following three questions, the Report declares:

1 Does standardization have the effect of forwarding technical scientific improvement of processes, techniques, and equipment?

2 Does standardization make possible a higher average standard of living?

3 Does standardization relegate problems already solved to their proper place, the field of routine, leaving creative faculties free for the problems still to be solved?

Taking into account only standardization arrived at by conscious, deliberate, selective process, and judging the effects in terms only of what is known about standardization as practiced today, "available evidence emphatically supports an affirmative answer to the three questions," the Conference Board concludes.

The danger that standardization may impede industrial and technical progress by tending to stereotype existing methods and designs is recognized, and to avoid it, the Board declares, existing standards and methods must be carefully and constantly checked with latest improvements, and machinery for constant and expeditious revision must be provided. For evidence that the standardization movement in the United States is successfully avoiding such stereotyping, the Board points to the fact that America's large industrial organizations which are most active in the field of standardization also are the ones which maintain the most active and progressive scientific research laboratories and constantly evolve new processes and commodities, and cooperate most actively with the various private and official bureaus in evolving new standards.

This study takes into account the fact that standardization of product, through its inseparable concomitant, mass production at lessened production cost, has shifted the major industrial problem away from production to marketing, with the net effect that the ratio of marketing costs to production costs is steadily increasing. This creates a situation which in part offsets the advantage of standardization itself, but which, the Board believes, may in part be remedied by simplifying and systematizing marketing technique. "To the extent that simplification of the channels of distribution may handle this difficulty, standardization can be used to raise still further the purchasing power of the daily wage."

In foreign trade, the existence of definite standards and specifications for materials and manufactured machinery and equipment has the effect of facilitating purchases both because of the lower price of the standardized products and the elimination of uncertainty as to the character of goods purchased. To a considerable extent, also, exporters may gain a wider market through adequate servicing with standard interchangeable parts. Standards of grade, quality, and size in many instances are necessary in order to build up national and international price quotations, which is true particularly in the case of agricultural products.

To maintain home markets, domestic producers may seek to persuade importers to conform to certain standardization tests sufficient to take up some of the wide price margin existing between the lowest level at which domestic merchants now can sell the domestic product and the highly advantageous level at which

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of February 15–March 15, 1929:

Aeronautical Symbols. (American Tentative Standard.)

Letter Symbols for Electrical Quantities. (American Standard.)

Sponsored by the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. Published by the A.S.M.E.

unrestricted importers can sell foreign-made goods. A raising of standards of their own products is resorted to in some cases by industries which come into sharp competition with industries producing new articles designed to supplant them.

The Board's study reveals the phenomenal growth, in all the industrial countries, particularly during and since the war, of a technique of standardization "which plays a basic and necessary part in machine industry." But it also implies a warning that the eventual effects are as yet not wholly clear; that a considerable part of the available data regarding its advantages had to be set aside as of dubious authenticity or as irrelevant, and that "there are many questions regarding the effects of standardization which cannot be answered, even tentatively, by an appeal to evidence."

Refrigerators

THE scope of this project, (B38), which is under the joint sponsorship of the Bureau of Home Economics of the Department of Agriculture and the American Society of Refrigerating Engineers, was approved as follows by the Standards Council at its December meeting:

a Inside cubic contents
b Area and spacing of shelves
c Dimensions of ice doors
d Cooperation with the Division of Simplified Practice in establishing outside dimensions
e The development of such standard methods of test as will be necessary to establish the data required in determining the refrigerators
f Specifications covering the more important data essential to the rating of refrigerators and appropriate for inclusion on a nameplate defining the leading characteristics of the box
g The setting up of standard grades or qualities for refrigerators
h Due consideration of questions of ruggedness and durability.

Such standards and specifications are to apply to household types of refrigerators and to such domestic-type refrigerators as are used in hospitals and hotels; but not to ice-making machinery or other specialized types of equipment. Such standards and specifications are to apply both to refrigerators cooled with ice and to self-acting or mechanical refrigerators employing a self-contained refrigerant.

Plumbing Equipment

WORK on the Standardization of Plumbing Equipment is steadily advancing. Chairman W. C. Groeniger has now completed the appointment of Sub-Committee No. 6 on Brass Plumbing Products. The new Sub-Committee is one of six functioning under the Sectional Committee on the Standardization of Plumbing Equipment which is sponsored jointly by the American Society of Sanitary Engineering and the A.S.M.E. Chairman Murphy plans to call this group together for its first meeting in the near future. The members of this Committee's well balanced personnel are:

JERE L. MURPHY, *Temporary Chairman*, Contracting Plumber
W. W. BOWERS, Scovill Manufacturing Company
L. A. CORNELIUS, President, Wolverine Brass Company
JOSEPH J. CROTTY, Vice-President, Central Foundry Company
A. E. HANSEN, Hydraulic and Sanitary Engineer
JOHN J. LONG, Vice-President, Hudson Brass Works
ROBERT H. MUELLER, Chief Engineer, Mueller Company
R. L. OTTKE, Standard Sanitary Manufacturing Company
WILLIAM R. WEBSTER, Vice-President, Bridgeport Brass Company
R. H. ZINKIL, Manager, Plumbing Engineering Department, Crane Company
HERBERT V. KOHLER, Vice-President, Kohler Company.

New Standards Yearbook for 1929

THE "Standards Yearbook" for 1929 is full of suggestions and data for all engaged in standardization. The many aspects of the subject call for a concise summary for busy men who most need to keep in touch with the latest advances in the standards field. The "Standards Yearbook" compiled by the National Bureau of Standards is designed to meet this need.

This is the third issue of an annual which has proved indispensable to all interested in any phase of standardization in America and abroad. It is in effect a standardization reference book, summarizing and bringing up to date current standardization activities and accomplishments in this country and elsewhere since the 1928 edition of the Yearbook. The keen and world-wide interest in standardization is shown by the surprisingly large sale of previous issues of which repeated reprinting has been necessary to meet the demand.

A special chapter (I) tells how the various countries standardize commercial weights and measures used in daily trade in the countless transactions of every-day life.

The chapter entitled "Standardizing Activities of Technical Societies and Trade Associations" is of special interest to readers of MECHANICAL ENGINEERING.

A brief account of international cooperation in standardization is followed by a synoptic summary of the activities of the national standards associations of the various countries.

The "Standards Yearbook" should be in the personal library of all engaged in work on standards, or concerned with their application in standardization. The contents of this volume comprise the following chapters:

I	Standardization of Commercial Weights and Measures Throughout the World
II	Standardizing the Tropical Year—The Calendar
III	International Standardizing Agencies
IV	National Standardizing Agencies
V	Federal Standardizing Agencies
VI	National Bureau of Standards
VII	Municipal, County, and State Agencies
VIII	General Standardizing Agencies
IX	Standardizing Activities of Technical Societies and Trade Associations
X	Bibliography on Standardization, 1928
XI	Index.

Copies of the "Standards Yearbook," 1929, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., price $1.00 postpaid.

The Pedestrian's Rights

UNDER a recent decision laid down by the U. S. District Court of Appeals, the pedestrian has the right-of-way whenever he steps from the curb while the "go" sign is with him.

Even if the lights change before he gets across the street he is still entitled to legal protection. In case of accident while crossing under such conditions, the driver is deemed negligent, according to the Court's decision.

The decree should not cause the pedestrian to be any less cautious than usual. This sorely tried and patient gentleman should "stop, look, and listen" exactly as in former days.

Let us not forget that legal protection and physical protection are two different things, suggests the National Safety Council. All the legal protection in the world will not compensate if the pedestrian gets run over.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-195: Since publication in the July and November, 1928, issues of MECHANICAL ENGINEERING, this paragraph has been further revised as follows:

P-195. *Heads.* The thickness of a blank unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, shall be calculated by the following formula:

$$t = \frac{8.33 \times P \times L}{2 \times TS}$$

where t = thickness of plate, in.
P = maximum allowable working pressure, lb. per sq. in.
TS = tensile strength, lb. per sq. in.
L = radius to which the head is dished, measured on the concave side of the head, in.

Where two radii are used the longer shall be taken as the value of L in the formula.

When a dished head has a manhole OR ACCESS opening, THAT EXCEEDS 6 IN. IN ANY DIMENSION, the thickness shall be increased by not less than 15 per cent of the required thickness for a blank head computed by the above formula, but in no case less than $^1/_8$ in. additional thickness over a blank head. Where a dished head has a flanged opening supported by an attached flue, an increase in thickness over that for a blank head is not required. If more than one manhole is inserted in a head, the thickness of which is calculated by this rule, the minimum distance between the openings shall be not less than one-fourth of the outside diameter of the head.

The radius to which the head is dished shall not be greater than the diameter of the shell to which the head is attached.

Where the radius L to which the head is dished is less than 80 per cent of the diameter of the shell, the thickness of a head with a manhole opening shall be at least that found by making L equal to 80 per cent of the diameter of the shell. This thickness shall be the minimum thickness of a head with a manhole opening for any form of head.

A blank head of a semi-elliptical form in which the minor axis of the ellipse is at least one-half the diameter of the shell, shall be made at least as thick as the required thickness of a seamless shell of the same diameter. If a FLANGED-IN manhole WHICH MEETS THE CODE REQUIREMENTS is placed in an elliptical head the thickness shall be the same as for an ordinary dished head with a radius equal to 0.8 the diameter of the shell and with the added thickness for the manhole.

The diameter of the shell to be used in applying these rules shall be the inner diameter of the shell for a head fitted to the inside of the shell, and the outer diameter of the shell for a head fitted to the outside of the shell.

Unstayed dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60 per cent of that for heads of the same dimensions with the pressure on the concave side.

IF A NOZZLE-TYPE MANHOLE WHICH MEETS THE CODE REQUIREMENTS IS PLACED ON AN ELLIPTICAL HEAD, THE THICKNESS OF THE HEAD SHALL BE THE SAME AS FOR AN ORDINARY ELLIPTICAL HEAD, PROVIDED, IN THE CASE OF SADDLE-TYPE RIVETED FLANGED MANHOLES, THE PROVISIONS OF PAR. P-260 ARE COMPLIED WITH. IN THE CASE OF NOZZLE-TYPE MANHOLES FORGE-WELDED TO THE HEAD, A REINFORCING COLLAR OF THE THICKNESS REQUIRED IN PAR. P-260 SHALL BE DRAWN SIMULTANEOUSLY WITH THE DRAWING OF THE FLANGE IN THE HEAD IN ORDER TO GIVE A RESULT AS SHOWN IN FIG. 1.

PAR. P-240. ADD THE FOLLOWING:

WHERE IT IS DESIRED TO APPLY STAYBOLTING TO A FURNACE 38 IN. OR LESS IN DIAMETER WHICH IS OF PROPER THICKNESS FOR THE REQUIRED WORKING PRESSURE UNDER THE ABOVE RULES, THE REQUIREMENTS OF THE CODE FOR THE STRESS ALLOWED UPON AND THE SPACING OF THE STAYBOLTS SHALL BE DISREGARDED.

PAR. P-314. REVISED:

P-314. The feedwater shall be introduced into a boiler in such a manner that the water will not be discharged directly against surfaces exposed to gases of high temperature, or to direct radiation from the fire, or close to riveted joints of shell or furnace sheets.

WHEN [in] a horizontal-return tubular boiler EXCEEDS 36 IN. IN DIAMETER, the feedwater shall discharge at about three-fifths the length from THAT END OF THE BOILER WHICH IS SUBJECTED TO THE HOTTEST GASES OF THE FURNACE [the front head] (except a horizontal-return tubular boiler equipped with an auxiliary feedwater heating and circulating device), above the central rows of tubes [when the diameter of the boiler exceeds 36 in.]. The feed pipe shall be carried through the head or shell FURTHEST FROM THE POINT OF DISCHARGE OF THE FEEDWATER [near the front end] in the manner specified for a surface blow-off in Par. P-307, and be securely fastened inside the shell above the tubes.

PAR. P-328. REVISED:

P-328. A water-tube boiler shall have the firing doors [furnace inspection doors and clinker doors] of the inward-opening type, unless such doors are provided with substantial and effective latching or fastening devices or otherwise so constructed as to prevent them, when closed, from being blown open by pressure on the furnace side.

THESE LATCHES OR FASTENINGS SHALL BE OF THE AUTOMATIC

POSITIVE LOCKING TYPE, HAVING A LATCH OR BOLT IN A FIXED BRACKET ON THE DOOR FRAME OR FURNACE FRONT. THE LATCH OR BOLT SHALL BE DEPENDENT UPON GRAVITY OR COUNTERWEIGHTED. FRICTION CONTACTS, LATCHES OR BOLTS ACTUATED BY SPRINGS SHALL NOT BE USED. THE FOREGOING REQUIREMENTS FOR LATCHES OR FASTENINGS SHALL NOT APPLY TO COAL OPENINGS OF DOWN DRAFT OR SIMILAR FURNACES.

ALL OTHER DOORS, EXCEPT EXPLOSION DOORS, NOT USED IN THE FIRING OF THE BOILER, MAY BE PROVIDED WITH BOLTS OR FASTENINGS IN LIEU OF AUTOMATIC LATCHING DEVICES.

EXPLOSION DOORS NECESSARILY PROVIDED TO RELIEVE FURNACE PRESSURE, IF LOCATED IN THE SETTING WALLS, WITHIN 7 FT. OF THE FIRING FLOOR OR OPERATING PLATFORM, SHALL BE PROVIDED WITH SUBSTANTIAL DEFLECTORS TO DIVERT THE BLAST.

PAR. H-3. REVISED:

H-3. The maximum allowable working pressure shall not exceed 15 lb. per sq. in. on a steel-plate boiler built under these rules to be used for low-pressure steam heating.

The maximum allowable working temperature at or near the outlet of a hot-water steel-plate boiler shall not exceed 250 deg. fahr., NOR [or] the maximum allowable working pressure 160 lb. per sq. in.

PAR. H-28. REVISED:

H-28. A manhole shall be placed in the front head below the tubes of a horizontal-return tubular boiler 48 in. or over in diameter. There shall be a manhole in the upper part of shell or head of a fire-tube boiler over 48 in. in diameter, except a vertical fire-tube boiler, or except a boiler used exclusively for hot-water heating where there is no steam space.

A boiler of the locomotive or firebox type, EXCEPT ONE SET IN BRICK OR OTHERWISE SO CONSTRUCTED AS TO RENDER SUCH OPENINGS INACCESSIBLE, shall have one handhole or washout plug near each corner in the lower part of the water leg and at least one opening near the line of the crown sheet.

Vertical fire-tube or similar-type boilers shall have at least three handholes or washout plugs in the lower part of the water leg and at least two handholes or washout plugs near the line of the lower tube sheet.

PAR. H-120. REVISED:

H-120. All boilers shall be plainly and permanently marked with the manufacturer's or distributor's name and the maximum allowable working pressure. All letters and figures shall be at least $^{5}/_{16}$ in. high.

The maximum allowable working pressure shall be stamped, cast, or irremovably attached to the front and rear cored sections of vertical sectional cast-iron boilers and on the dome section of horizontal sectional cast-iron boilers. The marking of maximum allowable working pressure on cast-iron boilers suitable for use for steam or water shall be as follows:

(FORM OF STAMPING)

Boilers suitable for use as water boilers only shall be marked as follows:

(FORM OF STAMPING)

All boilers built according to these rules, and no other boilers, shall be EITHER marked, STAMPED, OR cast with the symbol as shown in Fig. H-2A.

Stamps for the official symbol shown in Fig. H-2A are obtainable from the American Society of Mechanical Engineers.

When a[n] CASING [insulating] or other form of covering [is] APPLIED TO A BOILER IS SO ARRANGED THAT IT IS NOT DESIRABLE TO PROVIDE AN OPENING THROUGH WHICH THE REQUIRED STAMPING OF THE BOILER PARTS MAY BE VIEWED, THE REQUIRED STAMPING SHALL ALSO BE PLACED ON A NON-FERROUS PLATE, NOT LESS THAN 3 IN. X 4 IN. IN SIZE, IRREMOVABLY ATTACHED TO THE FRONT PORTION OF THE BOILER OR ITS CASING [used, that portion of the front cored section of vertical sectional cast-iron boilers, and the dome cored section of horizontal sectional cast-iron boilers bearing the foregoing marking, shall either be provided with a removable cover plate or be left uncovered].

PAR. M-14. REVISED:

M-14. Each miniature boiler for operation with a definite water level shall be equipped with a glass water gage for determining the water level. The lowest permissible water level shall be at a point one-third of the height of the shell, except where the boiler is equipped with internal furnace, when it shall be not less than one-third of the length of the tubes above the top of the furnace. IN THE CASE OF SMALL STEAM GENERATING UNITS OPERATED ON THE CLOSED SYSTEM WHERE THERE IS INSUFFICIENT SPACE FOR THE USUAL GLASS WATER GAGE, WATER LEVEL INDICATORS OF THE GLASS BULL'S-EYE TYPE MAY BE USED.

PAR. U-3. REVISED:

U-3. Safety valves shall be of the direct spring-loaded type, designed with substantial lifting device so that disc can be lifted from its seat by the spindle not less than one-eighth the diameter of the valve when the pressure on the vessel is 75 per cent of that at which the safety valve is set to blow. IF THE SAFETY VALVE IS TO BE USED FOR RELIEF OF LIQUID PRESSURE, NO LIFTING DEVICE IS REQUIRED.

PAR. U-12. THE FOLLOWING NEW PARAGRAPH IS TO TAKE PLACE OF PRESENT.

PAR. U-12.

U-12. SPECIFICATIONS ARE GIVEN IN PARS. S-1 TO S-285 OF SECTION II OF THE CODE FOR THE IMPORTANT MATERIALS USED IN THE CONSTRUCTION OF BOILERS AND PRESSURE VESSELS, AND WHEN SUCH MATERIALS ARE USED FOR THE CONSTRUCTION OF UNFIRED PRESSURE VESSELS, THEY SHALL CONFORM THERETO.

PAR. U-13. FORMER PAR. U-12 TO BE INCLUDED IN PAR. U-13 AS SECTION *A* AND PRESENT PAR. U-13 AS SECTION *B*, AS FOLLOWS:

[U-12] U-13*A*. Plates for any part of a riveted vessel required to resist stress produced by internal pressure shall be of flange- or firebox-quality steel conforming with the Specifications for Steel Boiler Plate given in Pars. S-5 to S-17 of Section II of the Code, except as provided in [PAR. U-13]. SECTION B.

[U-13] *B*. Steel plates for any part of a pressure vessel which is to be constructed with other than riveted joints shall be of the quality specified for the particular kind of joint used.

PAR. U-20. REVISED:

U-20. *For Internal Pressure.* The maximum allowable working pressure on the shell of a pressure vessel shall be determined by the strength of the weakest course, computed from the thickness of the plate, the efficiency of the longitudinal joint, the inside diameter of the course, and the maximum allowable unit working stress.

$$\frac{S \times t \times E}{R} = \text{maximum allowable working pressure, lb. per sq. in.}$$

where S = maximum allowable unit working stress in lb. per sq. in.

= 11,000 lb. per sq. in. for steel plate stamped 55,000 lb. per sq. in., 10,000 lb. per sq. in. for steel plate stamped less than 55,000 lb. per sq. in., and [9000 lb.

per sq. in.] for materials used in seamless shells, ONE-FIFTH OF THE MINIMUM OF THE SPECIFIED RANGE OF THE TENSILE STRENGTH OF THE MATERIAL.

t = minimum thickness of shell plates in weakest course, inches

E = efficiency of riveted longitudinal joint

R = inside radius of the weakest course of the shell, in., provided the thickness of the shell does not exceed 10 per cent of the radius. If the thickness is over 10 per cent of the radius, the outer radius shall be used.

NOTE: When the safe working pressure for welded or brazed vessels is to be determined, E will be omitted from the formula and the values for S in Pars. U-68, U-82, or U-94 will be substituted for the values given above. For seamless shells, E equals 100 per cent.

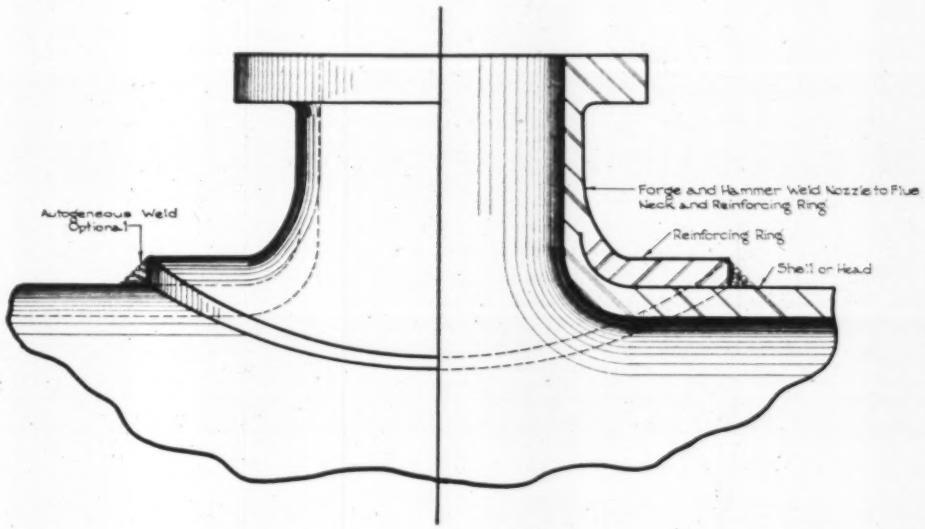

Autogeneous Weld (Optional)
Forge and Hammer Weld Nozzle to Flue Neck and Reinforcing Ring
Reinforcing Ring
Shell or Head

FIG. 1

PAR. U-36. REVISED:

U-36. The thickness OF [required in an] a BLANK unstayed dished head WITH THE PRESSURE ON THE CONCAVE SIDE, when it is a segment of a sphere shall be calculated BY THE FOLLOWING FORMULA [as follows:]

$$t = \frac{8.33 \times P \times L}{2 \times TS}$$

[For P × L equal to or less than $\frac{1}{2}$ S

$$t = \frac{3PL}{4S}$$ for pressure on concave side

$$t = \frac{5PL}{4S}$$ for pressure on convex side

[For P × L greater than $\frac{1}{2}$ S

$$t = \frac{PL}{2S} + \frac{1}{8}$$ for pressure on concave side

$$t = \frac{5PL}{6S} + 0.2$$ for pressure on convex side

where t = thickness of plate, in.

P = maximum allowable working pressure, lb. per sq. in.

TS = TENSILE STRENGTH, LB. PER SQ. IN.

L = radius to which the head is dished, MEASURED ON THE CONCAVE SIDE OF THE HEAD, in.

[S = maximum allowable unit working stress of 11,000 lb. per sq. in. for steel plate stamped 55,000 lb. per sq. in., and 10,000 lb. per sq. in. for steel plate stamped less than 55,000 lb. per sq. in.]

Where two radii are used, the longer shall be taken as the value of L in the formula.

When a dished head has a manhole OR ACCESS opening, THAT EXCEEDS 6 IN. IN ANY DIMENSION, the thickness [as determined by these rules] shall be increased by not less than 15 PER CENT OF THE REQUIRED THICKNESS FOR A BLANK HEAD COMPUTED BY THE ABOVE FORMULA, BUT IN NO CASE LESS THAN $\frac{1}{8}$ IN. ADDITIONAL THICKNESS OVER A BLANK HEAD [over that called for by the formulas.] WHERE A DISHED HEAD HAS A FLANGED OPENING SUPPORTED BY AN ATTACHED FLUE, AN INCREASE IN THICKNESS OVER THAT FOR A BLANK HEAD IS NOT REQUIRED. IF MORE THAN ONE MANHOLE IS INSERTED IN A HEAD, THE THICKNESS OF WHICH IS CALCULATED BY THIS RULE, THE MINIMUM DISTANCE BETWEEN THE OPENINGS SHALL BE NOT LESS THAN ONE-FOURTH OF THE OUTSIDE DIAMETER OF THE HEAD.

THE RADIUS TO WHICH THE HEAD IS DISHED SHALL NOT BE GREATER THAN THE DIAMETER OF THE SHELL TO WHICH THE HEAD IS ATTACHED.

Where the radius L TO WHICH THE HEAD IS DISHED is less than 80 per cent of the diameter of the shell [to which the head is attached] the thickness OF A HEAD WITH A MANHOLE OPENING shall be at least that found [by the formula] by making L equal to 80 per cent of the diameter of the shell. THIS THICKNESS SHALL BE THE MINIMUM THICKNESS OF A HEAD WITH A MANHOLE OPENING FOR ANY FORM OF HEAD.

A BLANK HEAD OF A SEMI-ELLIPTICAL FORM IN WHICH THE MINOR AXIS OF THE ELLIPSE IS AT LEAST ONE-HALF THE DIAMETER OF THE SHELL SHALL BE MADE AT LEAST AS THICK AS THE REQUIRED THICKNESS OF A SEAMLESS SHELL OF THE SAME DIAMETER. IF A FLANGED-IN MANHOLE, WHICH MEETS THE CODE REQUIREMENTS, IS PLACED IN AN ELLIPTICAL HEAD THE THICKNESS SHALL BE THE SAME AS FOR AN ORDINARY DISHED HEAD WITH A RADIUS EQUAL TO 0.8 THE DIAMETER OF THE SHELL AND WITH THE ADDED THICKNESS FOR THE MANHOLE.

THE DIAMETER OF THE SHELL TO BE USED IN APPLYING THESE RULES SHALL BE THE INNER DIAMETER OF THE SHELL FOR A HEAD FITTED TO THE INSIDE OF THE SHELL, AND THE OUTER DIAMETER OF THE SHELL FOR A HEAD FITTED TO THE OUTSIDE OF THE SHELL.

UNSTAYED DISHED HEADS WITH THE PRESSURE ON THE CONVEX SIDE SHALL HAVE A MAXIMUM ALLOWABLE WORKING PRESSURE EQUAL TO 60 PER CENT OF THAT FOR HEADS OF THE SAME DIMENSIONS WITH THE PRESSURE ON THE CONCAVE SIDE.

IF A NOZZLE TYPE MANHOLE WHICH MEETS THE CODE REQUIREMENTS IS PLACED ON AN ELLIPTICAL HEAD, THE THICKNESS OF THE HEAD SHALL BE THE SAME AS FOR AN ORDINARY ELLIPTICAL HEAD PROVIDING, IN THE CASE OF SADDLE TYPE RIVETED FLANGED MANHOLES, THE PROVISIONS OF PAR. U-56 ARE COMPLIED WITH. IN THE CASE OF NOZZLE-TYPE MANHOLES FORGE-WELDED TO THE HEAD, A REINFORCING COLLAR OF THE THICKNESS REQUIRED IN PAR. U-56 SHALL BE DRAWN SIMULTANEOUSLY WITH THE DRAWING

OF THE FLANGE IN THE HEAD IN ORDER TO GIVE A RESULT AS SHOWN IN FIG. 1.

PAR. U-37. REVISED:

U-37. When dished heads are of a less thickness than called for by Par. U-36 they shall be stayed as flat surfaces, no allowance being made in such staying for the holding power due to the spherical form UNLESS ALL OF THE FOLLOWING CONDITIONS ARE MET:

A THAT THEY BE AT LEAST TWO-THIRDS AS THICK AS CALLED FOR BY THE RULES FOR UNSTAYED DISHED HEADS.

B THAT THEY BE AT LEAST $^7/_8$ IN. THICK.

C THAT THROUGH STAYS BE USED ATTACHED TO THE DISHED HEAD BY OUTSIDE AND INSIDE NUTS.

D THAT THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL NOT EXCEED THAT CALCULATED BY THE RULES FOR AN UNSTAYED DISHED HEAD PLUS THE PRESSURE CORRESPONDING TO THE STRENGTH OF THE STAYS OR BRACES SECURED BY THE FORMULA FOR BRACED OR STAYED SURFACES GIVEN IN PAR. U-40 USING 70 FOR THE VALUE OF *C*.

If a dished head is formed with a flattened spot or surface [for the attachment of a connection or flange], the diameter of the flat spot shall not exceed THAT ALLOWABLE FOR FLAT HEADS AS GIVEN BY THE FORMULA IN PAR. U-36 (the formula for flat heads to be published later on) [the value of p as given in the formula in Par. U-40 or in Table U-3 for the pressure and thickness of head involved.]

PAR. U-38. REVISED:

U-38. The corner-radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the [plate] thickness OF THE MATERIAL IN THE HEAD [up to t = $^1/_2$ in.]; BUT IN NO CASE LESS THAN 6 PER CENT OF THE DIAMETER OF THE SHELL [for thicker plates the corner radius shall not be less than 3 per cent of *L* in Par. P-195 and in no case less than $1^1/_2$ in.]

PAR. U-39. REVISED:

U-39. A FLANGED manhole opening in a dished head shall be flanged to a depth measured from the outside OF THE HEAD AT THE MAJOR AXIS of not less than 3 times the required thickness of the head FOR PLATE UP TO $1^1/_2$ IN. IN THICKNESS. FOR PLATE EXCEEDING $1^1/_2$ IN. IN THICKNESS THE DEPTH SHALL BE THE THICKNESS OF THE PLATE PLUS 3 IN. A MANHOLE OPENING MAY BE REINFORCED BY A RIVETED MANHOLE FRAME OR OTHER ATTACHMENT IN PLACE OF FLANGING.

PAR. U-41. REVISED:

U-41. *Staybolts.* The ends of staybolts or stays screwed through plate SHALL EXTEND BEYOND THE PLATE NOT LESS THAN TWO THREADS WHEN INSTALLED, AFTER WHICH THEY shall be riveted over or upset by AN equivalent process WITHOUT EXCESSIVE SCORING OF THE SHEETS; OR THEY SHALL BE fitted with THREADED nuts THROUGH WHICH THE BOLT OR STAY SHALL EXTEND.

PAR. U-44. REVISED:

U-44. The formula in Par. U-40 was used in computing Table U-3 for steel plate stamped 55,000 lb. per sq. in. Where values for screwed stays with ends riveted over are required for conditions not given in Table U-3, they may be computed from the formula and used, provided the pitch does not exceed $8^1/_2$ in. WHERE THE STAYBOLTING OF SHELLS IS UNSYMMETRICAL BY REASON OF INTERFERENCE WITH BUTT STRAPS OR OTHER CONSTRUCTION, IT IS PERMISSIBLE TO CONSIDER THE LOAD CARRIED BY EACH STAYBOLT AS THE AREA CALCULATED BY TAKING THE DISTANCE FROM THE CENTER OF THE SPACING ON ONE SIDE OF THE BOLT TO THE CENTER OF THE SPACING ON THE OTHER SIDE.

PAR. U-53. REVISED:

U-53. All vessels for use with compressed air, 18 in. in diameter, or over, and not exceeding 36 in. in diameter, shall have a handhole in the shell or head, or a manhole or at least two plugged threaded openings of not less than 2 in. pipe size. WHEN TWO THREADED OPENINGS ARE USED THEY SHOULD BE LOCATED IN THE HEADS, OR IN THE SHELL NEAR THE HEADS.

All such vessels less than 18 in. in diameter shall be provided with at least two handholes, or two inspection holes, properly located for inspection, the inspection holes to be not less than $1^1/_2$ in. pipe size, unless the vessels have removable heads or cover plates.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 587 (Reopened), 609 (Annulled), 616–618 as formulated at the meeting on January 10, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 587 (Reopened)

Inquiry: Will it not be permissible in the markings of cast-iron low-pressure heating boilers to place the marking either on the jacket or the firing door of the new types of sheet-metal-jacketed boilers? In the new line of sheet-metal-jacketed boilers that are now on the market, it is difficult to so place the marking as to comply with the requirement in Par. H-120 of the Code that it shall be left uncovered or made readily accessible.

Reply: Par. H-120 specifically requires the marking to be stamped, cast or otherwise irremovably attached to the front and rear cored sections of vertical sectional cast-iron boilers and on the dome section of horizontal sectional cast-iron boilers. A revision of Par. H-120 is now under consideration which may, where casings are used, provide for additional markings on the casing, and under such conditions remove the requirement that the stamping required to be placed on the boiler be made accessible.

CASE NO. 609 (Annulled)

CASE NO. 616

Inquiry: Is it the intent of Par. P-296 of the Code that gage connections shall be of brass, copper, or bronze composition when they are normally filled with water but may be exposed to high-

pressure steam when blown for clearing the pipe of sediment and deposit?

Reply: It was the intent of this provision in Par. P-296 for brass, copper, or bronze composition that it should apply only to such connections as are never subjected to a temperature greater than that of saturated steam at a pressure of 250 lb., and not to exceed 406 deg. fahr.

CASE NO. 617

Inquiry: In the revised form of Par. P-200 of the Code, should the sentence that contains the requirement for the drilling of staybolts used in the waterlegs of water-tube boilers, have added thereto a provision that these telltale holes should extend 1/2 in. beyond the inside of the plate, or in the case of upset ends, extend 1/2 in. beyond the point of reduction in section?

Reply: It is the intent of the requirement in Par. P-200 for the drilling of the ends of staybolts used in the waterlegs of water-tube boilers, that the same provisions for the depth of drilling and relation of drilling to reduction of section, shall apply as in the case of staybolts in fire-tube-boiler waterlegs.

CASE NO. 618

Inquiry: Is it necessary, under the requirement in Par. P-254 of the Code, to remove the heads from the ends of a drum after the rivet holes have been finished, in order to remove the burrs? It is pointed out that where hammer-welded drums are used the heads are fitted to them with a small tolerance, so that it is difficult to remove the head for such a purpose.

Reply: Par. P-254 refers only to longitudinal joints in which the separation of the butt straps for cleaning out the burrs is mandatory.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Wages of Engineers

TO THE EDITOR:

In the December, 1928, issue of MECHANICAL ENGINEERING, on page 964, Mr. Crosby Field brings to light valuable data. Such endeavors certainly are a manifestation of a desire to arrive at the truth and to serve the Society through service to the interest and welfare of its individual members.

Already these data are leading Mr. Field to the right road. In his editorial in the July issue, "Personality" was stressed as the missing link in the engineers make-up, keeping him from entering private practice or attaining success in the employ of others. The facts he secured have made it clear to him, as well as to others, that engineers have an exceedingly small chance of securing a cecent living wage in the employ of others and must therefore find a way into business for themselves if they are to obtain any measure of just reward. How this is to be done is the problem at issue.

Referring to Mr. Field's figures of those working for themselves, and for others, in the medical, legal, and engineering professions (reproduced here for convenience), it will be seen that about 70 per cent of the physicians and 71 per cent of the lawyers in New York State are practicing for themselves, while only 9 per cent of the engineers are in private practice.

COMPARISON BETWEEN PROFESSIONS

Profession	Working for Themselves Number	Per cent	Working for Others Number	Per cent	Total
Medical	13,910	69.4	6,120	30.6	20,030
Legal	8,583	71.2	3,459	27.8	12,042
Architects	1,517	8.9	2,167	91.1	17,081
Engineers			13,397		

At various times the proportion of engineers in the employee class has been estimated to be between 91 and 98 per cent. If we are mindful of the greater opportunity the architects command for entering private practice, it is surely reasonable to believe the correct figure is close to 95 per cent. It is contended by many that even of the 5 per cent supposedly in practice, the majority are buying and selling machinery, etc.

However, for the sake of expediency, let it be granted that in private practice will be found the highest figure the most ardent will venture to state, i.e., 9 per cent. The facts brought to light then compel all to agree to the following:

First: seventy per cent of the physicians are working for themselves.

Second: seventy-one per cent of the lawyers are working for themselves.

Third: nine per cent of the engineers are working for themselves.

Why are only 9 per cent of the engineers working for themselves? Is it by choice? Is it not common knowledge among the older engineers that every young man entering engineering, dreams that some day he is to have a practice of his own. Yet starting with this end in view at least 50 per cent abandon engineering during the first 25 years after leaving school; of those remaining only 9 per cent at the very most are fortunate enough to find a way into private practice.

Now Mr. Field in his July contribution states that either capital or personality is necessary for obtaining a share in the ownership of any enterprise. The engineer hasn't capital, for he never receives enough to accumulate any, so that's out.

This intangible factor "Personality" is the only rainbow left. Is it possible that at least 70 per cent of the older professions have this attribute, while only about 5 per cent of those entering the engineering profession possess it? Would Mr. Field have us believe that 91 per cent of our engineers have insufficient "Personality?" After reflecting upon his own facts, I don't believe he will.

The answer, then, cannot be "Personality," but rather that the engineering societies have not followed the methods of the medical and legal societies in guarding and fostering the material interests of their members to the end that the profession may give its undivided efforts to service.

New York, N. Y.

THOMAS H. NORMILE.[1]

Errata

ON PAGE 813 of the October, 1928, issue of MECHANICAL ENGINEERING, the price of "Water Purification," a treatise by Joseph Ellms, published by the McGraw-Hill Book Co., New York, is given as $3. It should have been given as $7 postpaid.

In the February, 1929, issue, on page 107, through a misprint, it is stated that Orville Wright's flight in the *Kitty Hawk* was made in 1908; it should of course have been 1903.

[1] Mechanical Engineer, Bureau of Water Supply. Assoc-Mem. A.S.M.E.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Fuels

Stoker-Fired Midwestern Coals

F-6 Under what conditions are underfeed stokers economically justifiable on midwestern coals such as those of Indiana, Illinois, Oklahoma, etc.? What maximum efficiencies have been obtained, and under what conditions of load factor and ash fusion? What did the maintenance run under these conditions?

It has been the experience of the writer's company that the midwestern bituminous coals such as those of Indiana, Illinois, and Oklahoma are not satisfactory coals for inclined underfeed stokers. These coals have been burned with fairly good results on single-retort underfeed stokers such as the type E in cases where the combustion rates were not too high. The chief difficulty with these coals is the low fusion point of the ash. Usually the fusion temperature is so low that combustion rates ordinarily obtained with multiple-retort underfeed stokers make these coals unsuitable for this type of stoker. Burned on forced-draft chain-grate stokers, however, they usually give very good results. (H. R. Towse, Manager, Combustion Engineering Corporation, New York City.)

Power

Power-Plant Depreciation[1]

P-1 What is the first cost per horsepower and the proper depreciation and obsolescence to allow on modern steam plants in sizes of 5000, 10,000, and 25,000 kw., particularly very modern types with air preheaters and the like?

[1] This subject has been discussed in a previous issue.

This answer will deal only with the part of the inquiry concerning obsolescence. The important element in the determination of proper obsolescence is the use of the power plant. Where the plant works in a highly competitive field, such as central-station work, it is necessary to maintain the plant at the peak of efficiency. The central station is all the time competing with the individual plant, even when the individual plant does not really exist, which means that unless the central station can deliver current cheaper than an individual plant would do it, there will be a tendency for the latter to develop. Because of all this, if a plant has become obsolete in design to the extent that it does not operate as economically as would a more modern plant, there is an advantage in scrapping it, which means that a high obsolescence factor has to be adopted.

On the other hand, take a power plant of an automobile manufacturing company. In that case the cost of power per unit manufactured is so comparatively low that even an appreciable variation, say, 25 per cent, would be barely felt. It has been estimated that the cost of power in making a Ford automobile is less than $1.00, and obviously 25 cents per car would not mean very much. On the other hand, the question of reliability is paramount, because a failure of power lasting for even one hour would be a very costly proposition in many ways. The result is that if the steam plant operates in a reliable manner there is no good reason for scrapping it and replacing it by another plant merely to save a small fraction of a cent per kilowatt of power generated. In such a case, therefore, the obsolescence factor will be low.

Another element that must be taken into consideration in steam plants of the central-station type is the character of the community. Where the growth of the community is a steady one, a comparatively low factor of obsolescence may be adopted. Where, however, this growth is rapid, it is a question whether to build a large unit, say, 25,000 or 50,000 kw., to provide for future growth and operate it on part load for a time, or to build a smaller unit to take care of existing and proximate demands, with the idea of scrapping it and replacing it by a bigger unit when the proper time comes. If the first policy is adopted the operating efficiency may have to be comparatively low, but the factor of obsolescence will likewise be low; in the second case, a high factor of obsolescence will have to be adopted. (L. C., New York, N. Y.)

Wood Industries

Holding Power of Wood Screws

WI-3 Is there any information on the holding power of wood screws later than that given in Marks' "Mechanical Engineers' Handbook," Third Edition?

The information on the holding power of wood screws in the March, 1929, issue supplements that which appeared in the November, 1927, issue, and the two cover application to thirteen of the most important woods. Inasmuch as lumber is sold by inch measurements in every port of the world and the data given in the last article are worthless until considerable conversion has been done, the writer submits the following version of the data in terms of American practice.

$$H = R\,(MD + b)$$

in which H = holding power in pounds per inch of screw embedded
R = a factor for the wood's compressive strength
M = product of a constant and the specific weight
D = diameter of the screw in inches
b = a constant.

Values of these factors for different woods are as follows:

Wood	b	M	R
Oak	1.35	6.6	342
Fir	1.36	5.7	218
Larch	1.68	3.6	316
Teak	1.48	6.7	302
Elm	1.49	5.5	375
Ash	1.58	7.4	297
Beech	1.88	9.1	370

From the foregoing table, the several factors for substitution in the formula are obtained. These take the place of the factors s, P, and a in the original article (b remaining the same), but they are actually conversions that may be applied readily to our measurements and screw sizes. In using this equation, it is well to remember that the result H is the number of pounds that would just pull the screw out by tearing, or compressing, the wood. The results obtained in this way correspond closely with the tabular matter given in the review of the Fairchild paper, which paper also gave the best sizes of lead holes to use and the decreased holding power when screws are set in the end grain. (Donald A. Hampson, Consulting Engineer, Middletown, N. Y.

Miscellaneous

Dry-Ice Manufacturing Plants

M-4 How is the product known commercially as "dry ice" manufactured? What is the chief item of the present cost, and what factors may be expected to enter into any reduction of cost to the consumer?

An excellent item on this interesting subject appears on page 871 of the November, 1928, issue of MECHANICAL ENGINEERING. The information was taken from a paper appearing in the August, 1928, issue of *Refrigerating Engineering*, published by The American Society of Refrigerating Engineers, 37 West 39th St., New York City. While the paper covers the subject in a general way, it is quite possible that additional information may be brought out through discussion in this department. It is hoped that refrigerating engineers in a position to throw additional light on manufacturing costs and possible future trends will add their comments to those already published. (EDITOR.)

Chromium Plating as a Corrosion Preventive

M-5 A manufacturer of small calculating machines has encountered what seems to be an electrolytic consuming action in addition to normal oxidation. Could this be reduced by either using a combination of metals most neutral to this action, or by plating the various components with chromium? Are there any tables giving a comparison of this action in the various metals?

Since a combination of metals is used in this case, it is almost impossible in our country, with the moisture of the air quite high, and the fact that salts and acids are contained in the atmosphere, to counteract the marked corrosion which will take place due to the difference in the potentials of the metals involved. Unfortunately there is no literature of any value on this subject, due largely to the fact that the latter is very much involved.

It is very difficult to make any definite recommendation without being able to examine the particular sample discussed; nevertheless, the writer believes that chromium plating the entire part composed of the several metals will be of value. At least, this has been the experience in other cases. For example, the writer has had on test for observation for over two years a composite metal fixture composed of one section of brass, one of copper, two of Britannia metal, all four parts being connected by soft solder. The fixture is completely covered by a light chromium plate. The resistance to corrosion has been very remarkable, and there has not been the slightest indication of deteriorating of any of the parts. Nevertheless, chromium plating a composite fixture of this kind is not an easy matter, and should be left to an expert familiar with the procedure. (Colin G. Fink, consulting metallurgist, research engineer, New York, N. Y.)

Questions to Which Answers Are Solicited

Boiler-Tube Failures

F-7 What specific instances can be quoted, when using distilled-water make-up, of the blistering or failure of boiler tubes directly exposed to the radiant heat of the furnace? Instances are desired either on the first two rows of boiler tubes, on the water walls, or on water screens, either with stoker, pulverized-fuel, or oil firing. Quote circumstances and method of eventual solution.

Boiler Corrosion Due to Lack of Deaeration

F-8 On boilers without economizers fed through open feed-water heaters operating at 210 deg. fahr., or thereabouts, has there ever been evidence of corrosion due to lack of deaeration? If so, under what conditions and circumstances?

Uses for Waste Gypsum

M-6 For what purposes is the waste gypsum collected from the tables in plate-glass manufacturing plants used?

Sealing Glass Panels in Display Refrigerators

M-7 In the manufacture of display refrigerators, what methods are employed to seal double-walled glass panels and doors to prevent infiltration of air between the panes and the consequent frosting of the glass?

Temperature as Related to Friction

M-8 What relation exists between friction and temperature in the case of two metal specimens in sliding contact under unlubricated conditions?

Dust Collectors

MH-2 Centrifugal separators are being considered for installation in a dust-collecting system. Possible arrangements involve the use of one oversize separator or two small ones placed in tandem. Which arrangement is considered the better, and why?

Stresses in Oil-Well Casings

PT-1 What methods are recommended for determining the types of stresses causing failure of oil-well casings at depths of 2000 to 3000 ft.?

Compound Cylinders on Mallet Locomotives

R-1 Why have compound cylinders remained on Mallet engines to a greater degree than on other types?

Poppet Valves in Locomotive Cylinders

R-2 What advantages are claimed for poppet valves when used in locomotive cylinders?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

ELMER A. SPERRY, *President*
ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

COMMITTEE ON PUBLICATIONS:
E. D. DREYFUS, *Chairman* F. V. LARKIN
W. A. SHOUDY, *Vice-Chairman* W. H. WINTERROWD
L. C. MORROW

PUBLICATION STAFF:
C. E. DAVIES, *Managing Editor*
FREDERICK LASK, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or .... printed in its publications (B2, Par. 3).

"What It's All About"

EVER since the beginning of the year, MECHANICAL ENGINEERING has appeared in two sections. Section Two, which, in spite of its single-sheet form, must be so dignified because of Post Office regulations, represents an attempt to summarize the subject-matter of the month's issue. To emphasize this essentially informative function, the title "What It's All About" has appeared on every supplement.

Section Two is frankly an experiment and is undergoing development. Every month a slightly different attack has been made on the method of treatment. Every month some feature of the contents of MECHANICAL ENGINEERING has been stressed. Every month the suggestion has been made that the sheet be passed on to some one who does not regularly receive the Journal. Written so that non-technical persons can understand it, the supplement aims to be interpretative not only of the contents of a technical journal but also of modern engineering.

Summer School for Mechanical Engineering Teachers

UNDER this title there was published in the February issue a notice of the 1929 session of the summer school for engineering teachers conducted by the Society for the Promotion of Engineering Education. The school this year will be held at Purdue University, June 27 to July 18, and will be devoted to mechanical engineering. The program is to be carried out in three divisions: heat-power engineering, machine design, and production engineering.

The opportunity afforded young instructors of refreshing their ideals and of contact with the masters of the teaching profession, learning from them the methods which have brought success in the class room, is an exceptional one. Of particular interest is the division devoted to production engineering, in which there is probably less standardization of curriculum and method than in either of the other branches. In an age of production, with new courses being introduced into almost every engineering school, the experiences to be gained at Purdue should do much for a sane and practical development of this branch of engineering education.

Mechanical Springs

THE story is told that a mechanic, upon having difficulty in adjusting the tension of a spring, complained to his foreman that springs were too "sentimental." The foreman knew of course that the "sentiment" was entirely within the man and not in the spring. To the lay mind, springs seem to represent the live or "sentimental" phase of mechanical design because of the reason that the energy content of the usual spring is sufficiently small to be sensed by direct contact. Thus human beings do not ride on steam- or gas-engine pistons, but on springs placed under the car frame and in the cushion seats. There has hardly been a person since the latter part of the 17th century who has not been fascinated by the significance of the co-functioning of the main and balance springs in their timepieces. The automobile, the principal cause of our great prosperity today, contains over a hundred springs, the most important of which are the valve and suspension springs. Our most modern means of transportation, the airplane, also depends upon the efficient operation of valve springs.

Mechanical springs are the most important and widely used of all our mechanical elements. Manual and automatic telephone systems, business machines, railway and power-plant equipment, as well as contrivances for domestic or household comfort, are only a few of the numerous and diversified classes of apparatus in which springs play an important part. Little wonder, then, that the initiative taken by the A.S.M.E. in appointing a Special Research Committee on Mechanical Springs barely five years ago had an immediate and profound effect on industry. The first act of the Committee in segregating the finely dispersed and obscure spring art had the effect of making it easily discernible as a distinctly separate phase of mechanical design in need of considerable research. Recognition of the spring art as such was followed by widespread support, technically and financially, of the Committee's research program. Individual and commercial research efforts were directly and indirectly traceable to the Committee's cooperative program. The greatly increased number of articles and papers on springs published in recent years is only part evidence of this fact.

JOS. KAYE WOOD.[1]

"Energy From the Atom"

IN SOME way the general public has gotten the idea that if the atom could be broken up an enormous amount of energy would result. One often hears the statements that the atomic energy contained in a pound of water is sufficient to drive a 10,000-kw. plant for a year, or ten years, or a hundred years, depending on the optimism of the person who makes the statement. While unquestionably a very large amount of energy is absorbed in the formation of an atom, it has become clearer and clearer as our knowledge of atomic structure increased that what is called a "breakdown" of the atom is possible but will

[1] Consulting Engineer, New York, N. Y. Assoc-Mem. A.S.M.E. and Chairman of its Special Research Committee on Mechanical Springs.

not release any energy. In an article entitled "Sources of Power" in MECHANICAL ENGINEERING, May, 1928, p. 358, the following statement was made:

> As little energy can be produced by the breakdown of an atom in any of the common elements encountered on the earth as there can be produced energy by trying to burn, for example, carbon dioxide. True, there is good reason to believe that the enormous amount of heat given out by the sun is the result of the breakdown of atoms, but there we are dealing not with the common elements, such as hydrogen, carbon, nitrogen, and the like, but with an entirely different group, namely, radioactive elements, which are apparently elements that have not yet reached the stage of interatomic stability, and of which hitherto only insignificant traces have been found on the earth. If this is so, then there is only very little hope for obtaining energy from the breakdown of any of the atoms known to occur in quantity on the earth.

This view is now supported by no less an authority than Dr. R. A. Millikan, professor of physics at the California Institute of Technology. At a meeting of the New York Society of Arts and Sciences, February 22, 1929, Dr. Millikan stated:

> Einstein's equation and Aston's curve alone, the former due partially to Mr. Michelson, the latter representing super-refinement in physical measurement of the sort that Michelson is famous for, enable us to conclude definitely that there is no energy available to man through the disintegration of any of the common elements.
>
> Man will presumably some day learn to disintegrate them, but he will have to expend energy upon them to do it. There is no appreciable energy available to man through atomic disintegration. Radium, it is true, releases about a million times as much energy per gram in disintegrating as carbon does in burning, but there isn't enough of it nor of any radioactive substance to more than keep a few corner popcorn men continuously going.
>
> On the other hand, a practically unlimited supply of energy would be available to man if the hydrogen in water and elsewhere on the earth could unite to form helium, nitrogen, oxygen, and the other common elements. This, we think, is just what is happening in interstellar space and thereby producing the observed cosmic rays, but the foregoing cosmic-ray facts seem to indicate that this process cannot take place on earth, and if this is true, then in the future as in the past man will depend entirely upon the sun for his supply of available energy.

High-Pressure Boilers

AN INTERESTING contrast in the attempts in this country and in Europe to generate steam at high pressures is afforded by the papers by Moultrop and Havliček which are published in this issue.

The paper by Moultrop is a frank discussion of the operating experiences at the Edgar Station of the Edison Electric Illuminating Company of Boston. The plant with its 1200- and 1400-lb. boilers has been described many times and its principal features are well known. What have not been so well known, except by those closely in touch with the station and the manufacturers who supplied the equipment, are the actual operating experiences which pioneering in a field filled with many real and imagined difficulties is certain to occasion. It is typical of the spirit which animates modern engineering that Mr. Moultrop should discuss his problems so frankly. He points out that, as would be expected, the anticipated difficulties were so well guarded against that they did not occur. By calling attention to the troubles which did develop, Mr. Moultrop has made other engineers his debtors. More papers written from this point of view of this one would be appreciated.

The paper by Havliček describes a 1700-lb. station in Czechoslovakia in which a Löffler boiler is used. The European attack on the problem of steam generation at high pressure has been radically different from that followed in this country. While we have attempted to adapt standard types of equipment to the requirements of a more severe service, European engineers have made a careful study of these requirements and have produced designs which are radical departures from those for lower-pressure service. Thus there have been developed the Benson boiler, generating steam at the critical presence and built without drums; the Schmidt boiler, in which a closed circuit from the high-pressure element where steam is formed, through a lower-pressure element where it is used to evaporate water for expansion in the turbine, eliminates the scaling troubles experienced when any but pure distilled water comes in contact with high-temperature surfaces; and the Löffler boiler, described and illustrated in the Havliček paper, which introduces a steam pump into the circulation system.

Experience with high-pressure steam generation has been too limited to justify a prediction of the line of development which the ultimate high-pressure boiler will follow. The technical and economic problems involved are far from being solved. That there is an increasing appreciation of the advantages of high-pressure steam and a real, widespread interest in the possibilities of its use, cannot be doubted.

Auto Speed Trials at Daytona

THE amazing performance of the *Golden Arrow*, driven by Segrave at a speed in excess of 231 miles per hour, together with the tragic ending of the attempt made to beat even that speed by Lee Bible, have attracted the attention of the world to auto speed trials. One may ask what, if any, reason there is for such trials outside of the attendant publicity. There can be little doubt as to the measure of real value behind such attempts, for there is more to them than the mere craze for speed. We have definitely reached the point where fast motor transportation is becoming a vital link in the communication system of the country. Whole sections of the country are beginning to depend completely on motor transportation, as there is a growing distaste among railroads to building short lines or feeder lines through thinly populated districts, the general impression being that automobiles can provide a better and quicker means of transportation than railway feeder lines. This leads on the one hand to an increasing congestion on the highways, which can be relieved only by a faster movement of traffic, and on the other hand to a demand for faster cars. It is because of this that the formerly nearly uniform top speed limit of around 25 miles per hour in open country was raised to 35 in Indiana, 45 in Florida, and 70 in some counties of Texas. Now a man who is driving a car at 70 miles an hour naturally wants to be absolutely certain that mechanically his car is able to stand up under that speed, and to him the best proof of this is a trial under which some car has safely operated at speeds way above that at which he is running. In other words, Segrave's run in the *Golden Arrow* at 231 miles an hour proves—psychologically, if not logically—that the *Speed Demon* in which Citizen John Smith is riding can be counted upon not to fly apart at 50 miles. Further, there is no question that a trial like Segrave's does indicate the extremely high stage of motor engineering, particularly in the art of balancing and tire making, which we have already reached.

Large-Size Total Heat-Entropy Diagram Now Available

MANY inquiries have been received concerning the total heat-entropy diagram published in the February issue with J. H. Keenan's paper on "A Revised Mollier Chart for Steam, Extended to the Critical Point." This diagram has been reproduced on a special bond paper and on a scale sufficiently large to be workable (22 in. × 33½ in.), and copies may be obtained at reasonable cost by applying to the Sales Publications Department of the A.S.M.E., 29 West 39th St., New York, N. Y.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Materials and Design in Turbo-Generator Plant

MATERIALS AND DESIGN IN TURBO-GENERATOR PLANT. By O. Lasche and Walter Kieser. English edition by A. L. Mellanby and W. Roylands Cooper. Oliver & Boyd, Edinburgh and London, 1927. Cloth, $7\frac{1}{2} \times 10\frac{1}{2}$ in., 204 pp., illus. 24s. net.

REVIEWED BY C. FRANCIS HARDING[1]

THE third edition of this book—enlarged and rewritten—contains much valuable material which is not easily to be found elsewhere. It deals mainly with the selection and testing of materials, but it also contains information regarding the shaping and proportioning of parts in high speed turbo-generators which should be of the greatest help to the designer of such machinery.

The authors have brought together a large amount of material of unusual value to engineers. The illustrations of the destruction of beta brass, page 145, warrants special mention. It should be said that much of the non-uniformity in the published results and also in the field observations on the corrosion of different brasses is traceable to segregations of zinc-rich areas in the alloys. This is due in part to wrong composition and in part due to uneven cooling rates. The author clearly demonstrates the cause of early failure in some brasses and bronzes. The effect of high operating temperatures on alloys and how this differs from the corrosive action of impurities in the water and steam, is very well brought out by the authors in discussing the causes of failure of turbine blades.

A whole chapter is devoted to the design and construction of rotors for a-c. turbo-generators, and another chapter takes up in detail the important factors entering in the design of turbine bearings. Electrical features are not discussed, but the treatment of the mechanical design of high-speed generating units is excellent.

Books Received in the Library

AEROPLANES, SEAPLANES AND AERO ENGINES. By Capt. P. H. Sumner. Crosby, Lockwood & Son, London, 1929. (Science of Flight, vol. 2.) Cloth, 6 × 9 in., 292 pp., illus., 25s.

After a historical introduction, this book discusses the principles of aerodynamics, the airscrew, types of engines, the general design and construction of aircraft, rigging, modern types of aeroplanes and seaplanes, and aeronautical instruments. The book is descriptive, rather than theoretical, but contains a large amount of information on current craft, and is profusely illustrated.

[1] Head, School of Electrical Engineering, Purdue University, Lafayette, Ind.

BAUELEMENTE DER FEINMECHANIK. By O. Richter. V.D.I. Verlag, Berlin, 1929. Bound, 7 × 10 in., 576 pp., illus., tables, 29r.m.

This volume is a first attempt to provide the instrument maker with a systematic presentation of the elements of instruments, similar to the well-known books on the elements of machines. It treats successively of the materials used, connections, bearings, driving mechanisms and regulating devices, giving descriptions of a great variety of practical methods, with the necessary data for the designer. The book will be valuable to manufacturers and designers of typewriters, sewing machines, phonographs, meters, optical instruments, and similar apparatus.

BIBLIOGRAPHY OF METALLIC CORROSION, comprising references to papers on ferrous and non-ferrous corrosion (including methods of protection) published up to the end of 1927. Greatly enlarged from a bibliography prepared for the British Non-Ferrous Metals Research Association and privately issued to its members. By W. H. J. Vernon. Edward Arnold & Co., London; Longmans, Green & Co., New York, 1928. Cloth, 6 × 9 in., 341 pp., $8.40.

This bibliography is the work of a skilled investigator of corrosion, who has brought to its compilation and annotation unusual qualifications for the task. The result is a work that will prove indispensable to practically every one in the metal industries or interested in the preservation of metal structures.

The bibliography is arranged chronologically under four topics; the types of corrosion and the factors influencing it, the corroding medium, the metal or article corroded, and protective methods. Numerous annotations and introductory notes are given, and there are sufficient cross-references. Over 3800 entries are included.

DEVELOPMENT OF GOVERNMENTAL FOREST CONTROL IN THE UNITED STATES. By Jenks Cameron. Johns Hopkins Press, Baltimore, 1928. (Institute for government research. Studies in Administration.) Cloth, 6 × 9 in., 471 pp., $3.

A history of government policy in dealing with forests from the settlement of America down to the present. The author presents an intensely interesting story of the struggle between freedom and control of forests, showing how the legend of the inexhaustibility of our wood supply has influenced thought throughout our history.

DISCOVERY OF THE RARE GASES. By Morris W. Travers. Edward Arnold & Co., London, 1928. Longmans, Green & Co., New York. Bound, 9 × 11 in., 128 pp., illus., $6.

An interesting account of Sir William Ramsay's work on the rare gases, covering the period from the commencement of the work that led to the discovery of argon up to the discovery of neon. The story is based on Ramsay's laboratory notebooks and the recollections of the author, who was an active participant in

much of this work. The book is interesting, not only for its historical value, but as a record of how discoveries are actually made.

ENGINEERING ENGLISH. By John Hubert Scott. John Wiley & Sons, New York, 1928. Cloth, 6 × 9 in., 321 pp., $2.75.

This is an interesting and unusual book. Professor Scott presents a course in composition, covering two semesters, which is carefully planned to train the student to express his ideas accurately and correctly, in a pleasing manner. The presentation of the material is unusually definite and complete, due attention is given to matters of mechanical form, and much general information on the correct use of English is included. The book will be helpful to every writer.

EXHAUST STEAM ENGINEERING. By Charles S. Darling. John Wiley & Sons, New York, 1929. Cloth, 6 × 9 in., 431 pp., illus., diagrams, tables, $7.50.

An extended presentation of methods for utilizing waste heat by back-pressure engines, exhaust-steam turbines, steam accumulators, and distribution systems. The author writes from the point of view of the user rather than from that of the manufacturer. His aim is to cover the problems associated with the choice of machinery and the disposition of plant in a manner that will enable the owner to ascertain that he is utilizing his fuel to the best advantage.

INDEX TO A.S.T.M. STANDARDS AND TENTATIVE STANDARDS. Issued by the American Society for Testing Materials, Philadelphia, Pa., as of September 1, 1928. 6 × 9 in., 96 pp.

This pamphlet constitutes a combined index to all A.S.T.M. standards and tentative standards in effect as of September 1, 1928. The standards appear in Parts I and II of the 1927 Book of A.S.T.M. Standards, except those which were adopted or revised in 1928, which appear in the 1928 Supplement to Book of A.S.T.M. Standards. The tentative standards appear both in the Proceedings (Part I) for the year in which they were submitted or last revised and in the 1928 Book of A.S.T.M. Tentative Standards. A complete list of the 542 standards and tentative standards indexed appears in the 1928 Year Book and in the 1928 Supplement to Book of A.S.T.M. Standards.

INDUSTRIEÖFEN, bd. 1: Grundlegende Theorien und Bauelemente. By W. Trinks. V.D.I. Verlag, Berlin, 1928. Cloth, 6 × 8 in., 347 pp., illus., diagrams, 16r.m.

A German translation of the first volume of "Industrial Furnaces," published in English in 1923.

MANUFACTURING COSTS AND ACCOUNTS. By A. Hamilton Church. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 516 pp., graphs, forms, $6.

This is a discussion of the underlying principles of cost accounting, intended to introduce the student to the why and wherefore of the subject and to give him a general view of it, rather than to describe specific systems in detail. The relation of cost accounts to the general accounting system is explained.

The new edition has additional chapters on departmentalization, costing methods, and graphic methods of showing costs. The text has been thoroughly revised throughout.

MESSUNG MECHANISCHER SCHWINGUNGEN. By Hermann Steuding. V.D.I. Verlag, Berlin, 1928. Cloth, 6 × 8 in., 500 pp., illus., 28r.m.

This book obtained the prize offered in 1925 by the Verein Deutscher Ingenieure for the best critical investigation of methods and apparatus for measuring mechanical vibration. It is a convenient and thorough review both of the literature on the subject and of the methods and apparatus in practical use.

After an interesting classification of methods and apparatus from the viewpoints of physical principles and applications, the author first considers seismometry. The general theory of apparatus for measuring vibration is then discussed and criteria established for judging it. In the following chapters the individual methods, arranged by their uses, are reviewed. The fields considered are biology and physiology, varying stresses in structures and machines, acoustics, periodic vibrations in machinery, and indicators for engines. A valuable bibliography of over fourteen hundred references is included.

MÉTHODÉS ET PROCÉDÉS MÉTALLURGIQUES. By M. Régnauld. Gauthier-Villars & Co., Paris, 1929. Paper, 6 × 10 in., 342 pp., illus., diagrams, 60fr.

A textbook on ferrous metallurgy. The raw materials, refractories, ferrous alloys, fuels, and methods of mechanical treatment are described concisely.

NOMOGRAPHIE. By M. Fréchet and H. Roullet. Armand Colin, Paris, 1928. Paper, 5 × 7 in., 208 pp., diagrams, 9fr.

A beginner's manual on the construction and use of monographs. The book explains the principles clearly and shows how they may be applied in practice. The joint work of a mathematician and an engineer.

OUTLINES OF PAINT TECHNOLOGY. By Noël Heaton. Charles Griffin & Co., London; J. B. Lippincott Co., Philadelphia, 1928. Cloth, 6 × 9 in., 400 pp., illus., $8.

This book originated in an attempt to revise Hurst's "Painters' Colours, Oils, and Varnishes," and retains the general plan and character of that work, although it is entirely rewritten. It is a general guide for students of paint technology, in which the reader will find practical information on the raw materials and their methods of manufacture, and on the manufacture of paints, varnishes, and lacquers. The book covers a wide scope and its information, while presented briefly, is carefully selected and useful.

PHOTOMICROGRAPHS OF IRON AND STEEL. By Everett L. Reed. John Wiley & Sons, New York, 1929. Cloth, 6 × 9 in., 253 pp., illus., tables, $4.

This book contains over two hundred photomicrographs of iron and steel, some of which have been subjected to mechanical and thermal treatments according to standard practices, the heat treatments having generally been those recommended by the Society of Automotive Engineers. The collection is useful for reference purposes to producers and users of steel.

PITMAN'S TECHNICAL DICTIONARY OF ENGINEERING AND INDUSTRIAL SCIENCE IN SEVEN LANGUAGES. Isaac Pitman & Sons, London and New York, 1928–29. Paper, 8 × 10 in.; 36 issues complete the volume; 15 parts already published. 75 cents each. Bound volumes to sell for about $30.

Sir Isaac Pitman and Sons are issuing, in fortnightly parts, a new technical dictionary, which they expect to complete early in 1929. The dictionary covers the entire field of engineering and will contain some two thousand pages of technical terms, in English, French, German, Italian, Russian, Spanish, and Portuguese. The equivalents appear accurate and the book will be a welcome addition to the translator's equipment.

PRÉCIS DE CONSTRUCTION, CALCUL ET ESSAIS DES AVIONS ET HYDRAVIONS. By J. Guillemin. Gauthier-Villars & Co., Paris, 1929. Paper, 7 × 10 in., 442 pp., illus., tables, 100fr.

A handbook for designers and builders which gives concisely a great amount of data in practical form. The author first treats of materials, describing their properties, uses and the standards of use. The forms of airplanes, their construction and the con-

struction of their parts are then treated, after which the design of aircraft is treated in detail. Finally, methods of testing are given.

PUMPEN-ANLAGEN. By Fr. Krauss. Walter de Gruyter & Co., Berlin and Leipzig, 1928. Cloth, 4 × 6 in., 124 pp., illus., diagrams, 150r.m.

By solving a collection of carefully chosen practical problems, this little book gives instruction in the proper evaluation, use, installation, and testing of pumps for all ordinary purposes.

DER QUECKSILBERDAMPF-GLEICHRICHTER, vol. 2; KONSTRUKTIVE GRUNDLAGEN. By Kurt E. Müller-Lübeck. Julius Springer, Berlin, 1929. Bound, 6 × 9 in., 350 pp., illus., diagrams, 42r.m.

Having considered the theory of mercury arc rectifiers very fully in his first volume, Mr. Müller devotes the second to their construction. He first discusses the principles of design, giving chapters on voltage characteristics, wave characteristics, power characteristics, and the short-circuit current, and following these with a discussion of design itself. After this he takes up questions of construction and of the erection of rectifier installations. The final chapter is a description of the great rectifying station of the Berlin railroads.

THE ROLE OF SCIENTIFIC SOCIETIES IN THE SEVENTEENTH CENTURY. By Martha Ornstein. University of Chicago Press. Bound, 6 × 9 in., 1928. 308 pp., $3.

It was during the seventeenth century that the experimental method of studying science was introduced, and the change was due, not to the universities, but rather to the work of independent workers banded together in scientific societies. The present book is intended to show how science advanced during that century, what part was played by individual scientists, and what was done by societies in Italy, England, France, and Germany. The beginning of the scientific journals are traced, and the attitude of the universities toward the experimental sciences is discussed.

SPHERICAL HARMONICS. By T. M. MacRobert. E. P. Dutton & Co., New York, 1927. Cloth, 6 × 9 in., 302 pp., $4.50.

This book aims to provide a text on the elements of the theory of Fourier series, Bessel functions, and spherical harmonics, with their applications to mathematical physics, so far as this can be done without using the method of contour integration.

THEORY OF LIGHT. By Thomas Preston. Fifth edition, edited by Alfred W. Porter. Macmillan Company, London and New York, 1928. Cloth, 6 × 9 in., 643 pp., $8.

A new edition of a well-known textbook, carefully revised and brought up to date. The book is intended for students beyond the elementary grade with some knowledge of higher mathematics. To such readers it offers a connected account of the most important researches of former times, which will enable him to study recent original investigations and theories.

THEORY OF PROBABILITY. By William Burnside. University Press, Cambridge, England; Macmillan Co., New York, 1928. Cloth, 6 × 9 in., 106 pp., $3.50.

This small volume represents a manuscript which Professor Burnside had practically completed before his death and which is now published by the Cambridge University Press. Professor Burnside's interest in the subject apparently was awakened during his study of military questions during the World War. As his interest grew, he ultimately set himself to make a systematic account of the theory of probability as it presented itself to him. Among the topics are direct and indirect methods of calculating probabilities, methods of approximation, the probability of causes, probabilities connected with geometrical causes, the theory of errors, and Gauss' law.

TREATISE ON THE ANALYTIC GEOMETRY OF THREE DIMENSIONS, vol. 1. By George Salmon. Seventh edition, revised by R. A. P. Rogers. Longmans, Green & Co., London and New York, 1928. Cloth, 6 × 9 in., 470 pp., $5.

The seventh edition of this classic shows little change from its predecessor of 1914. Misprints have been corrected and a few paragraphs made more explicit.

TREMPE RECUIT REVENU..... vol. 2; Pratique. By Léon Guillet. Dunod, Paris, 1928. Paper, 7 × 10 in., 296 pp., illus., plates, 75fr.

After considering the theory of heat treatment in his first volume, Professor Guillet devotes the present book to practical methods. He discusses the choice of furnaces, the structural and operative characteristics of the different types, the composition of baths, apparatus, and various methods of tempering and annealing. Failures in heat treatment and their remedies are explained, and control methods are set forth. A final chapter is devoted to shop organization.

ÜBER DIE ANLASSVORGÄNGE IN ABGESCHRECKTEN CHROM-UND MANGANSTÄHLEN. By Hans Goerisch. Julius Springer, Berlin, 1928. (Berichte aus dem Institut für Mechanische Technologie und Materialkunde der Technischen Hochschule zu Berlin. Heft 2.) Paper, 6 × 9 in., 36 pp., illus., diagrams, tables, 3.60r.m.

An investigation of the extent to which chromium and manganese affect changes in properties, especially length, that occur in hardened steel bars during annealing. The research has practical interest because it throws light on the more or less metastable condition of steel at ordinary temperatures, a question of importance to makers of gages and measures.

UNTERSUCHUNG DER VON SPRITZVERGASERN GELIEFERTEN ZERSTÄUBUNG. By J. Sauter. (Forschungsarbeiten. Heft 312.) V.D.I. Verlag, Berlin, 1928. Paper, 9 × 12 in., 30 pp., illus., diagrams, 5.50r.m.

Describes apparatus and methods used in an investigation of carburetors carried out at the Munich Technical Institute. The investigations were undertaken to determine the fineness of fuel division obtained with typical carburetors under conditions approximating usual working conditions. Results are reported, with suggestions for improving carburetors.

DER VERBRENNUNGSVORGANG IM GAS-UND VERGASER-MOTOR. By Wilhelm Endres. Julius Springer, Berlin, 1928. Paper, 7 × 10 in., 80 pp., diagrams, tables, 6.80r.m.

To determine mathematically the combined effect of the various factors that affect combustion in internal-combustion engines, such as the chemical properties of the fuel, the compression, the shape of the combustion chamber, etc., is very difficult. Dr. Endres, an experienced engine builder, here attempts to appraise the combined action of these various influences. The various formulas that he has derived make it possible to obtain a certain quantitative view of the phenomena of combustion in the engine.

DER ZÜNDVERZUG BEI FLÜSSIGEN BRENNSTOFFEN. By Richard Hartner-Seberich. (Forschungsarbeiten. Heft 299.) V.D.I. Verlag, Berlin, 1928. Paper, 9 × 12 in., 23 pp., illus., diagrams, 3.75r.m.

An experimental and analytical study of the time lag of ignition in engines using heavy-oil fuel. Experimentally, the author investigates the influence of such factors as initial temperature, initial pressure, and air motion on the lag. Experimental results indicated that the laws of heat transference determine the magnitude of the lag, so the author proceeds to determine mathematically the transfer of heat from the air to the fuel oil, and the part played by vaporization.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the Applied Mechanics, Management and Railroad sections of A.S.M.E. Transactions as published in its new form. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

APPLIED MECHANICS PAPERS

A Simplified Method of Determining Stresses in Rotating Disks. By M. G. Driessen. [Paper No. APM-50-10]

The stresses in rotating disks, such as the disks of steam-turbine rotors, are usually determined by the Donath method described by H. Haerle in *Engineering*, August, 9, 1918. The principal disadvantage of this method is that it does not give the required stresses directly, but depends upon making certain initial assumptions and working up to the final result by trial and error.

The purpose of this paper is, first, to shorten the various steps necessary in passing from one element of the disk to the next, second, to provide an alternative to this cut-and-try method, and third, to indicate a manner by which the results once obtained can be used for all conditions under which this disk is employed, i.e., for different loads at the circumference and for different speeds.

Vibration of Frames of Electrical Machines. By J. P. Den Hartog. [Paper No. APM-50-11]

The paper gives a formula and curves for the calculation of the natural frequency of frames, with a consideration of the flexibility of the feet. As an illustration, an actual example met in practice is discussed in detail.

Evaluation of the Technical Worth of a Steel From Physical Test Data. By A. B. Kinzel. [Paper No. APM-50-12]

This paper shows how the various properties of steel may be used to help determine the most logical factor of safety. After describing the method used in the determination and making several specific applications the author states the following conclusions:

1 The technical worth of a given material for a given purpose may be expressed quantitatively.

2 In the consideration of material to be applied in service, the technical worth for a given purpose may be expressed either as the maximum allowable fiber stress or as the ability to withstand or absorb local stresses by plastic deformation.

3 Once the standard of comparison and proper weight exponents for a given application are determined by those qualified to do so, even those relatively inexperienced in the particular field may evaluate the worth of a given material by simple substitution in the formula.

4 The selection of material on a variable-strength and variable-ductility basis is more logical than on the basis of a fixed or proportional minimum ductility and variable strength.

Stresses in the Drive System of Three-Cylinder-Locomotives. By Fritz Loewenberg. [Paper No. APM-50-13]

In this paper the author analyzes the stresses set up in the side rods and driving axles of three-cylinder locomotives of the type in which all cylinders act upon the same axle, taking into consideration the small inaccuracies of fittings resulting in clearances and play and the elastic deformations produced. Formulas are derived and their application illustrated by means of numerical calculations. Systems with more than two axles are also considered.

The Range and Severity of Torsional Vibration in Diesel Engines. By Frederic P. Porter. [Paper No. APM-50-14]

A paper on this subject was presented by the author at the Spring Meeting of the A.S.M.E., White Sulphur Springs, Va., May 23 to 26, 1927, and was published in the Transactions of the Society, vol. 50, no. 17, paper no. APM-50-8. This earlier paper contains a paragraph entitled "Heavy Ring Connected to Shaft by Flexible Spokes." Since its publication the author has developed another treatment of this matter, which forms the subject-matter of the present paper.

Investigation of Insulated Walls. By Frank B. Rowley. [Paper No. APM-50-15]

This paper gives some of the research work at the University of Minnesota on the thermal properties of insulating materials and built-up wall sections for the type of construction used for houses in cold climates and for cold-storage work. A description of the types of test apparatus used is followed by a discussion of the results. A method is shown for converting from one set of results to another. The effect of moisture and temperature on the thermal conductivity of the materials is shown by test results. A group of walls tested by the hot-box method is discussed, showing in detail their construction and insulating value.

Stress Analysis in Electrical Rotating Machinery. By M. Stone. [Paper No. APM-50-16]

With the continuous trend toward larger and higher-speed power-generation units, new design problems have presented themselves—predominantly of a mechanical nature. Such problems are occupying the minds of mechanical engineers working in the field of electrical engineering, and provide an enormous field for development to which engineers in the next few years must devote themselves.

The work, in general, has taken two lines of improvements; (1) to increase the knowledge of the behavior of materials of construction, and (2) to estimate more accurately stress conditions by detailed analysis.

Although the author's discussion covers principally the analysis of stresses in electrical machinery, it is impossible to pass over the other main groups of mechanical problems—the problems concerning vibration and balancing of generators and motors—and these are briefly dealt with in the early part of the paper.

MANAGEMENT PAPERS

The Apprenticeship-Training Program of the Tri-City Manufacturers. By S. M. Brah. [Paper No. MAN-50-14]

This paper treats the subject in three principal sections: first, a description of the community problem; secondly, an explanation of the system of apprenticeship training; thirdly, the results of the training under this system.

An Industrial-Plant-Location Study. By Emmett B. Carter. [Paper No. MAN-50-15]

The authors gives results of an analysis illustrating the factors to be considered in locating a plant, those taken in the present study being: 1, Trade possibilities for expansion; 2, low distribution costs and speedy delivery; 3, cost and quality of raw material; 4, the first cost of the plant and the resulting overhead costs, and 5, the cost and quality of labor.

Manufacturing and Wage-Payment Methods as Practiced by the Hall-Scott Motor Car Company. By Alfred B. Celander. [Paper No. MAN-50-16]

The author gives details of the planning, production, materials handling, and inspection practice of a large establishment, as well as particulars of an incentive wage-payment system which has been employed with satisfactory results.

Motion-Study Principles and Their Application in a Department Store. By B. Eugenia Lies and Marie P. Sealy. [Paper No. MAN-50-17A]

The fundamental principles of motion study are first presented, and are subsequently illustrated in the report of a study which was made of a centralized cashiering system in the department store of R. H. Macy & Co., Inc., New York.

The case illustrating the principles described is presented in the second part of the paper. The factors affecting the work of the cashier are summarized and the results of the motion study discussed. Examples of the process and simultaneous motion-cycle charts are given. The changes which were made in the working equipment, the

work room, and the work of the cashiers are described, and the benefits which have resulted from the careful analysis are explained.

An Application of Motion Study to Group Work in Industry. By J. A. Piacitelli. [Paper No. MAN-50-17B]

The author emphasizes certain points in motion study and discusses the analysis of work in general, mentioning briefly some of the major differences in the various techniques and pointing out some of the limitations under which the analyst must work when making a study of an operation.

The Work Required to Operate Several Makes of Typewriters. By F. H. Norton. [Paper No. MAN-50-18]

This paper reports a series of carefully conducted tests made on five standard typewriters, manufactured by different companies and bought at retail stores, to determine the amount of work required for their operation. To eliminate the human element and to make it possible to measure the work involved, the typewriters were operated pneumatically by a specially designed apparatus which also recorded on a photographic film a curve whose integrated area was proportional to the work.

In order to interpret the results obtained, 25 typical business letters were analyzed to determine the average number of times each of the five operations studied was performed. It was then possible to determine the total work to type the average letter on each of the typewriters, and a table of these results is given.

The author points out that certain elements which are independent of the actual work of operating the typewriter but which seriously affect fatigue are not covered by the investigation. Recommendations are made as to adjustment and servicing of typewriters.

RAILROAD PAPERS

Electric Interlocking System. By R. J. Cullen. [Paper No. RR-50-10]

This paper gives particulars of an installation by the Boston & Albany Railroad at its new station in Springfield, Mass., in which the control of all switches and signals at both ends of the station is centralized in one plant.

Locomotive and Freight-Car Utilization. By C. B. Peck. [Paper NO. RR-50-11]

The termination of Federal control of the operation of the railroad of the United States early in 1920 was the beginning of a new era of railroad operation. One of the important characteristics of this new era is the attention which is being given to effecting a more intensive utilization of every facility which enters into the production of transportation. The author shows what the roads have accomplished in the more effective utilization of their locomotives and rolling stock since that time.

Car Retarders, A Recent Development in Railway-Yard Operation. By L. Richardson. [Paper No. RR-50-12]

The car retarder or track brake, which is dealt with in this paper, is one of those modern time- and labor-saving devices that have enabled the railways to reduce operating expenses in spite of rising costs of labor and materials. Although the first commercial installation in the United States was put in service in February, 1926, nearly all of the apparatus of this first installation is still in service. The design of this first apparatus has been substantially improved, and the improved design, which has been in service nearly a year, amply meets all requirements, showing that the retarder has successfully passed through the development stage and is now generally considered as an approved device for the efficient and economical operation of hump yards.

Locomotive Sparks. By L. W. Wallace. [Paper No. RR-50-13]

The annual loss due to fires alleged to have been started by locomotive sparks is stated in the paper to be approximately 12 million dollars. Numerous locomotive and laboratory tests have been made for the purpose of determining the behavior of such sparks, and the author presents some of the findings relating to the subject. It is his belief that under the most favorable circumstances it is very unlikely that a spark of sufficient size and temperature ever reaches the ground in a condition that will ignite even the most inflammable material beyond 65 ft. from the center of the track. Further, there is no direct relationship between wind velocity and spark distribution. Other facts which the author sets forth clearly disclose that it is exceedingly difficult to ignite inflammables with sparks of the size that pass through the ordinary locomotive netting, even at temperatures far exceeding those at which they escape from the locomotive stack. He also discusses other factors with regard to the distribution of sparks, their behavior under conditions of high temperature, color as a basis for judging the temperature of sparks, fire-weather forecasts, moisture content as a reliable index to a degree of inflammability, etc. He is of the opinion that sufficient data have now been accumulated from which fixed laws relating to the behavior of locomotive sparks may be formulated.

NOTE: Those who have not registered in the A.S.M.E. Applied Mechanics, Management, and Railroad Divisions, whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

To the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

Please send copies of papers checked below:

Applied Mechanics { [APM-50-10] [APM-50-11] [APM-50-12] [APM-50-13] / [APM-50-14] [APM-50-15] [APM-50-16] }

Management [MAN-50-14] [MAN-50-15] [MAN-50-16] [MAN-50-17] [MAN-50-18]

Railroad [RR-50-10] [RR-50-11] [RR-50-12]

PRINT name (Important).....

Street Address..... City.....

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

Mechanical Engineering Section

THE ENGINEERING INDEX furnishes a Weekly Card Index Service of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Items of particular interest to mechanical engineers are selected for presentation each month in this Mechanical Engineering Section. In operating The Engineering Index, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (while printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIRPLANE ENGINES

Efficiency. Thrust Horsepower and Engine Efficiency, J. M. Shoemaker. Aviation (Aeronautical Eng. Supp.), vol. 26, no. 3, Jan. 19, 1929, pp. 6–7, 1 fig. Maximum effective thrust per horsepower, or effective thrust available in aircraft power plant is discussed; high-speed engine with propeller driven at crankshaft speed is less efficient than slower turning propeller in same aircraft; high-speed direct-drive propeller may also suffer loss of efficiency due to excessive propeller tip speed; latest practice in regard to reduction gear ratios.

Heavy-Oil. Heavy-Oil Engines for Aircraft, D. R. Pye. Aeronautics (A.S.M.E. Trans.), vol. 50, no. 26, Sept.-Dec. 1928, pp. 45–47 and (discussion) 47–50, 2 figs. Early experimental work with single-cylinder research unit to explore possibilities of compression-ignition operation; alternative designs; results in single-cylinder experiments showing effect of maximum cylinder pressure upon brake m.e.p. and fuel consumption; fuel-valve and nozzle design; air swirl; valve mechanism; possibilities of two-stroke cycle; performance at altitude; earlier use of heavy-oil engines in airships probable.

AIRPLANE PROPELLERS

Design. Aircraft Propellers, C. H. Havill. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, Jan. 1929, pp. 17–23, 4 figs.; see also Aviation Eng., vol. 2, no. 1, Jan. 1929, pp. 7–12, 3 figs. Nearly all Army and Navy aircraft propellers of detachable-blade type; Navy has found it necessary to make its own designs; sources of designer's information; discrepancies between model tests and wind-tunnel tests; substitute propellers; strength of propellers; empirical formulas for maximum fiber stress; whirl test for strength; necessity for use of gearing; considerations applying to variable-pitch propellers.

Vortex Theory of Airplane Propellers (Zur Wirbeltheorie der Luftschrauben), T. Troller. Zeit. fuer Angewandte Methematik und Mechanik (Berlin), vol. 8, no. 6, Dec. 1928, pp. 426–430, 8 figs. Diagrams are presented showing results of calculation of induced speeds in axial direction, based on Prandtl's approximate method; there are cases in which more exact calculation is necessary, but in most cases it is believed that Prandtl's method is sufficiently accurate.

Manufacture. Making Micarta Airplane Propellers, R. L. Knight. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 409–411, 8 figs. Manufacture of micarta propellers is described; extreme care throughout manufacturing process to assure uniform and high-grade material, perfect balance of blades, and perfect fit of blades to hub; machining to fit blade to metal hub; final balancing and setting of pitch angle.

Metal. Technical Development of the Reed Metal Propeller, S. A. Reed. Aeronautics (A.S.M.E. Trans.), vol. 50, no. 26, Sept.-Dec. 1928, pp. 55–62, 14 figs. Details of aircraft propeller with solid, thin, and almost knife-like blades of forged or rolled duralumin or other aluminum alloys of similar type; development of metal propeller; propeller and its function; types of Reed metal propellers; materials of construction; methods of manufacture.

AIRPLANES

Alloys for Use in. The Use of Light Alloys in Aircraft From the Point of View of Corrosion, H. Sutton. Royal Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 217, Jan. 1929, pp. 38–54 and (discussion) 54–74, 19 figs. Value of various light alloys in aircraft construction and question of corrosion are discussed; aluminum and its alloys; restrictions of commercially pure aluminum; duralumin; aluminum-copper, silicon alloys; wrought aluminum-silicon alloys; wrought aluminum-copper-nickel alloys; aluminum casting alloys; protection of aluminum and aluminum alloys; magnesium alloys assuming increasing importance; influence of corrosion on fatigue properties.

Autogiro. The Autogyro, V. E. Bertrandias. Engrs. and Eng., vol. 46, no. 1, Jan. 1929, pp. 26–27 and (discussion) 27–28. Interesting points of this new windmill plane are described; autogiro plane possesses valuable qualities of stability at large angles of incidence and ease of landing.

Control, Automatic. Device for the Automatic Control of Airplanes, A. Gradenwitz. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 495, Jan. 1929, 6 pp., 6 figs. partly on supp plates. Control device of Franz Drexler has three switch buttons, with which three-part automatic control can be switched on or off in whole or part, leaving controls to be operated by hand or foot; for intermediate control, purely electric transmission used; each mechanism has special contact-making device by which reversing motor is set rotating; direct current produced by windmill-driven generator; provisions for correction. From Motorwagen, March 31, 1928, pp. 204–206.

Design. The Modern Aerodynamic Theory in Design, I. H. Driggs. Aviation (Aeronautical Eng. Supp.), vol. 26, no. 3, Jan. 19, 1929, pp. 2–5, 2 figs. Discussion of Prandtl theory with formulas developed from study of subject; rational formula for drag curve of airplane over useful range developed and from that minimum drag and consequently maximum L/D and velocity at which they occur; from resulting power equation value of minimum power and speed at which it occurs is found; wing area should be determined from speed of minimum power rather than landing speed desired; case of glider and soaring speed; minimum sinking speed for soarer.

Dope. Aircraft Dope and Finish Problems, E. G. Davis. Aviation Eng., vol. 2, no. 2, Feb. 1929, p. 10. Discussion of dope failures, and complete peeling of dope film away from fabric; this trouble was noticeable some 12 years ago, but disappeared with development of dopes after war, only to appear again now; military and naval aircraft free from these troubles; tendency of aircraft industry toward heavy, thick, smooth coatings which do not show any fabric is mechanically unsound.

Landing Gear, Caterpillar. A Caterpillar Landing Gear for Airplane, P. E. Lamarche, Jr. Aero Digest, vol. 14, no. 1, Jan. 1929, p. 88, 1 fig. Details of caterpillar tread device called "petin atterrisseur" developed by Louis Vinay, Paris; caterpillar tread is attached to landing-gear axle in such a way that it allows plane to pivot on its axis when it meets an obstacle; it can overcome obstacles on ground up to height of about 16 in. with ease; Westinghouse air brakes mounted on each caterpillar tread inside plates that form sides.

Metal Construction. Armstrong-Whitworth Metal Construction. Flight (Lond.), vol. 20, no. 52, Dec. 27, 1928, pp. 1083–1087, 28 figs. Typical Armstrong-Whitworth forms of metal construction and methods employed are described; both circular-section tubes and rolled or drawn strip used; tubular construction confined to fuselage; two types of mechanical joints; each side of fuselage built up on jigs; steel strip wing spar construction; heat treatment and rust protection.

Speed Control. Increasing Airplane Speed-Range, H. Alfaro. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, Jan. 1929, pp. 99–100. Devices for improving control at slow speed are discussed; recommendations made by Daniel Guggenheim Foundation for safety and efficiency of aircraft

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

cannot be met by present airplanes; wing flaps reduce stalling speeds; reducing parasite drag; glider design described.

Tail Surfaces. Fluttering of the Tail Surfaces of an Airplane and the Means for Its Prevention, F. N. Scheubel. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 498, Jan. 1929, 11 pp. and (discussion) 12–16, 12 figs. on supp. plates. Fluttering of tail surfaces, and especially of horizontal empennage, discussed; important to make fuselage as rigid as possible; more compact, round fuselage, like that of Curtiss racer, best for swift airplanes; elevator must be mounted somewhat farther forward where fuselage is thicker; stabilizer supported by V strut; continuous elevator axis; unbalanced elevator better. From Jahrbuch der Wissenschaftlichen Gesellschaft fuer Luftfahrt, Dec. 1926.

Two Practical Methods for the Calculation of the Horizontal Tail Area Necessary for a Statically Stable Airplane, W. S. Diehl. Nat. Advisory Committee for Aeronautics—Report, no. 293, 1928, 20 pp., 13 figs. Problem of calculation of horizontal-tail area necessary to give statically stable airplane is discussed; two entirely different methods are developed, and reduced to simple formulas easily applied to any design combination; detailed instruction are given for use of formulas, and all calculations are illustrated by examples; relative importance of factors influencing stability is also shown.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Anti-Corrosive. Choosing Corrosion-Resisting Alloys (Le choix des alliages résistant à la corrosion). Pratique des Industries Mécaniques (Paris), vol. 11, no. 10, Jan. 1929, pp. 407–411. Discussion of corrosion and its process; classification of alloys from corrosion standpoint; ferrous and non-ferrous alloys are discussed and action of various factors promoting corrosion.

Magnesium. See MAGNESIUM ALLOY CASTINGS.

ALUMINUM ALLOYS

Protective Coatings. Heat-Insulating Properties of Aluminum and Their Applications (Les propriétés calorifuges de l'aluminium et leurs applications), M. de Biran. Chaleur et Industrie (Paris), vol. 9, no. 103, Nov. 1928, pp. 413–417. Résumé of certain principles relating to heat transmission; aluminum foil and coatings; aluminum painting of furnaces, chimneys, gas pipe and producers; painting of heat-insulated surfaces; heat insulation of small tubes.

Aluminum-Silicon. Aluminum-Silicon Alloys: Their Properties and Some Applications, R. B. Deeley. Foundry Trade Jl. (Lond.), vol. 40, nos. 647 and 648, Jan. 10 and 17, 1929, pp. 29–32 and 49–51, 14 figs. See also Metal Industry (Lond.), vol. 34, nos. 3 and 4, Jan. 18 and 25, 1929, pp. 75–78 and 103–106, 6 figs. Modification treatment, which improves properties of aluminum-silicon alloys, consists of treating alloys containing from 5 to 20 per cent of silicon, in molten state, before casting with alkaline fluoride, or mixture containing alkaline fluoride with alkaline chloride, or even substance which under this treatment would yield alkaline fluoride. Paper presented before Inst. Brit. Foundrymen and Inst. of Metals.

Silicon-Aluminium Alloys, Dornauf. Metallurgist (Supp. to Engineer, Lond.), Jan. 25, 1929, pp. 6–7. Author's results relate principally to tensile properties and hardness, and are given in forms of graphs in which these properties are plotted as functions of amount of added elements; graphs relate throughout to sand-cast test bars; injurious effects of relatively small quantities of magnesium, tin and antimony, on both tensile strength and ductility are evident. Abstract translated from Zeit. fuer Metallkunde, Aug. 1928.

AMMONIA COMPRESSORS

Clearance Control. Clearance Control a Necessity for Constant-Speed Compressors, F. P. MacNeil. Power, vol. 69, no. 4, Jan. 22, 1929, pp. 136–138, 2 figs. Clearance pockets overcome difficulties experienced with adoption of constant-speed motor for ammonia-compressor drive; high compression ratios impair efficiency of compressor; size of clearance pockets; care must be taken not to design pockets too large; how changing capacity affects clearance control.

Design. Calculation of the Most Favorable Intermediate Pressure in the Case of Compound Compression for Ammonia Refrigerating Machines (Berechnung des guenstigsten Zwischendruckes bei Verbundkompression fuer NH-3 Kaeltemaschinen), H. Behringer. Zeit. fuer die gesamte Kaelte-Industrie (Berlin), vol. 35, no. 6, June 1928, pp. 111–113, 1 fig. See also translated abstract in Information on Refrigeration (Institut Int. du Froid)—Bul., vol. 9, no. 4, July-Aug. 1928, pp. 615–618. Reference is made to earlier article by R. Plank who suggested an ideal comparison cycle; tables of evaporation temperature are presented.

AUTOMOBILE ENGINES

Combustion Chambers. Engine Knock, W. A. Whatmough. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, pp. 10–13, 4 figs. Evidence that engine knock can be completely subjugated within limits set by heating of unburnt charge prior to and during propellant inflammation; Whatmough anti-knock design of combustion heads; comparison with other principles; combustion chambers may be flat or compact, with either short or long flame travel, prime essentials being "directed flow" during intake, compression, firing and exhaust strokes.

Cylinders, Honing. Finishing Cylinders by the Honing Process, C. G. Williams. Machy. (N. Y.), vol. 35, no. 5, Jan. 1929, pp. 359–360. Summary of modern practice in finishing cylinders by honing; types of honing machines; rates of spindle rotation and reciprocation; principles of construction of hone heads and abrasives used lubricant; new applications of process. Abstract of paper presented before Soc. Automotive Engrs.

Design. Methods of Obtaining Greater Power From a Given Engine, T. J. Litle, Jr. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, Jan. 1929, pp. 36–38 and (discussion) 38–40, 1 fig. Demand for increased car performance forces manufacturers to provide more powerful engines; increasing power without designing new engine by making increases in speed, volumetric efficiency, compression ratio, thermal efficiency and mechanical efficiency; increased valve lift, hydraulic valve gears, multiple carburetors, injection of vaporized fuel into cold air, cutting out fan at high speeds and use of supercharger are suggested; stiff bearings wasteful.

Diesel. See DIESEL ENGINES. Automotive.

Valve Springs. Notes on Valve-Spring Design, W. T. Donkin and H. H. Clark. Wire, vol. 4, no. 1, Jan. 1929, pp. 11–12 and 24–27. Author suggests designing of valve springs with frequencies so high that they will not vibrate until they have reached forced camshaft speeds; analysis of failures; laws of spring design; design as related to natural frequency; number of coils affects rate; how surge affects spring stresses. Abstract of two papers presented before Soc. Automotive Engrs.

Valves, Machining. Machining Motor-Car Engine Valves on Butterworth Automatics. Machy. (Lond.), vol. 33, no. 847, Jan. 3, 1929, pp. 437–439, 5 figs. Operations performed on two $1^1/_4$-in. bar automatics with slight modifications from standard design for machining automobile-engine valves; rate of production 34 per hour.

AUTOMOBILES

Bodies, Oxyacetylene Welding of. Producing All-Steel Automobile Bodies With Oxy-Acetylene, J. W. Meadowcroft. Am. Welding Soc.—Jl., vol. 8, no. 1, Jan. 1929, pp. 14–20, 5 figs. Statistics offered to designate the very important part oxyacetylene welding process plays in production of all-steel automobile bodies; direct comparison of total per cent of money expended in purchase of oxygen in comparison with yearly business; also review of various uses of oxyacetylene in departments of E. G. Budd Mfg. Co.

Brakes, Design of. Experiments With Self-Energized Brakes, C. G. Navatt. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, pp. 34–38, 20 figs. Description of series of experiments using momentum of vehicle as energizer of brake member itself; basic principle used is wedge interposed between fixed torque abutment and inside of brake drum; one drum equipped with six brake members, four forward and two in reverse; experiments with hydraulic instead of mechanical operation; correct place for brake energizer is within brake itself and independent of outside forces.

Springs, Manufacture of. Manufacture and Heat-Treatment of Automobile Leaf Springs, J. B. Bauen. Am. Mach., vol. 70, no. 6, Feb. 7, 1929, pp. 248–249. Springs fabricated in most uniform manner to give symmetrical action to finished product; automatic eye-forming machines; after steel is heated in automatically controlled oil-operated furnace, it is formed on machines that submerge leaves automatically into oil-cooling vat; continuous drawing furnace; finishing. Abstract of paper presented before Western Metals Congress.

Transmissions, Design of. Opinions Vary as to Best Type of 4-Speed Transmission. Automotive Industries, vol. 60, no. 4, Jan. 26, 1929, pp. 128–129. Review of Transmission Session of Detroit Meeting of Society of Automotive Engineers with brief abstracts of papers and discussion; desirability of using either four-speed gear box or two-speed rear axles to make higher road speeds with lower engine speeds possible, C. D. Peterson; instrument recently developed by University of Michigan for measuring sound of gears, F. A. Firestone.

AUTOMOTIVE FUELS

Alcohol. Utilization of Methyl Alcohol as a Carburant (Au sujet de l'utilisation de l'alcool méthylique comme carburant), P. Dumanois. Assn. des Chimistes de Sucrerie et de Distillerie—Bul. (Paris), vol. 45, no. 15, Sept. 1928, pp. 605–608. Effect of using methyl alcohol in automobile engine.

Anti-Knock Compounds. Metallic Colloids and Knock Suppression, H. L. Olin and W. J. Jebens. Indus. and Eng. Chem., vol. 21, no. 1, Jan. 1929, p. 43, 1 fig. Colloids were prepared by thermal decomposition of metallo-organic compounds at various given temperatures and stabilized by addition of small quant ties of raw rubber; working solutions of proper concentration were then made by diluting with gasoline; apparatus for testing motor fuels; anti-knock properties of nickel and lead.

Synthetic. It Costs 26 Cents a Gallon to Make Gasoline From Coal at Present, A. C. Fieldner. Nat. Petroleum News, vol. 21, no. 3, Jan. 16, 1929, pp. 69–70 and 72–73. Summary of results obtained, to date, in various processes for converting coal into liquid fuel; carbonization; hydrogenation and liquefaction by Bergius process; complete gasification and conversion of gases by pressure synthesis to methanol, synthol and other combustibles. Extracts from address in Montreal indexed in 1928 vol. of Eng. Index from various sources.

B

BAKELITE

Machining. The Machining of "Bakelite Laminated." Machy. (Lond.), vol. 33, no. 848, Jan. 10, 1929, p. 487. Description of methods of machining bakelite laminated is preceded by brief outline of its manufacture; planing and milling; turning and drilling; punching, shaving and shearing; producing bakelite surface finish.

Molding. Methods Used in Molding Bakelite Parts, R. A. Lowe. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 433–437, 5 figs. Presses for bakelite molding; molds employed; methods of ejecting parts from molds; accuracy of molded parts; molding vs. machining; methods of heating molds; molding threaded parts; recessing and coring cut costs; flow of bakelite must be considered in designing mold; avoiding trapped air difficulties.

BALANCING MACHINES

Rotors. Balancing Machines for Rotating Parts. Engineering (Lond.), vol. 127, no. 3286, Jan. 4, 1929, pp. 8–10, 4 figs. Gisholt Machine Co., of Madison, Wisconsin, are manufacturing a machine which is invention of B. L. Newkirk, and is suitable for balancing crankshafts, armatures and rotors of electrical machinery, flywheels, spindles, etc., up to 25 in. in diam., up to 32 in. in length between bearing supports, or 48 in. in overall length, and up to 1000 lb. in weight.

60-Ton Dynamic Balancing Machine for the Victoria Falls Power Company. Engineering (Lond.), vol. 127, no. 3287, Jan. 11, 1929, pp. 38–41, 15 figs. Particulars of what is claimed to be largest machine yet constructed for balancing of alternator and turbine rotors; constructed by Carl Schenk, Ltd., of Darmstadt, Germany, to order of Victoria Falls and Transvaal Power Co.; balancer consists of massive bed plate, at one end of which are mounted 500-hp. motor and gear box through which drive is communicated to rotor under test.

BEARINGS, ROLLER

Design. Failure by Fatigue and the Permissible Loading on Roller Bearings (Ermuedungsbruch und zulaessige Belastung von Waelzquerlagern), R. Mundt. V.D.I.-Zeit. (Berlin), vol. 73, no. 2, Jan. 12, 1929, pp. 53–59, 12 figs. Principles of numerical design of roller bearings; analysis of stresses causing wear and failure of roller bearings; repeated stresses and failure by fatigue; logarithmic chart for determination of permissible loads on roller bearings.

BLAST FURNACES

Bearings. Anti-Friction Bearings at Blast Furnaces, S. R. Cox, Jr. Blast Furnace and Steel Plant, vol. 17, no. 1, Jan. 1929, pp. 104–106, 15 figs. Auxiliary equipment is made more

efficient and maintenance problems are solved by use of roller bearings; positive lubrication assured; on blast furnace equipment they are contributing to low upkeep and maintenance costs on hot metal cars, cinder ladle cars, ore scale cars, ore transfer cars, Dwight Lloyd sintering machines, pig casting machines, McKee distributing tops, blast furnace skip cars, head sheaves, etc.

BOILER FEEDWATER

Treatment. Boiler Feedwater Treatment with colloids (Le traitement des eaux d'alimentation des chaudières par les colloides), A. Sauze. Pratique des Industries Mécaniques (Paris), vol. 11, no. 10, Jan. 1929, pp. 429–432, 5 figs. Description of process for colloidal treatment of water to remove its impurities by adsorption; filtrator apparatus is treated.

Experience With Sodium-Aluminate Treatment for Boiler-Feed Water, C. C. Spilman. Power, vol. 69, no. 3, Jan. 15, 1929, pp. 94–96. After study of water treatment it was decided in author's company, to base internal treatment on use of sodium aluminate in connection with soda ash; marked advantages shown are that there are less excess chemicals, less soluble salts, low hardness, less foaming, and less scale; external chemical treatment of feedwater, which has for its object removal (to lower limits of solubility) of all calcium and magnesium compounds, is considered.

BOILER PLATES

Embrittlement. Embrittlement Prevention in Steam Boilers, F. G. Straub. Power Plant Eng., vol. 33, no. 3, Feb. 1, 1929, pp. 173–174. Data from experience in use of following three laboratory methods to prevent embrittlement; maintenance of sodium sulphate to sodium carbonate alkalinity ratio, maintenance of definite phosphate concentration and maintenance of certain organic matter concentrations. Abstracted from Univ. of Ill. Eng. Experiment Station—Bul., nos. 155 and 157.

BOILERS

Control. Some Results With the Hagan Automatic Combustion Control System, T. R. Alexander. Indus. Chemist (Lond.), vol. 5, no. 48, Jan. 1929, pp. 29–31, 2 figs. Efficient combustion regulation is quite as important as steam regulation; British Xylonite Co., Ltd., has installed Hagan automatic combustion control in one of its boiler houses; plant consists of four Babcock land-type boilers; automatic gear; data given in table show clearly how automatic combustion control has improved operating conditions.

Design. Progress in Boiler Design (Fortschritte im Dampfkesselbau), E. Praetorius. Waerme (Berlin), vol. 52, nos. 1 and 2, Jan. 5 and 12, 1929, pp. 1–6 and 24–27, 12 figs. Results of research; high-pressure boilers; temperatures of superheated steam; increase in efficiency; economic and safety considerations; manufacture of boilers.

Drums, High-Pressure, Forging. Forging of Boiler Drums for Very High Pressure (Le forgage des bouilleurs de chaudières à très haut pression), C. Dantin. Génie Civil (Paris), vol. 94, no. 4, Jan. 26, 1929, pp. 77–81, 11 figs. Description of methods of making boiler tubes for boilers carrying steam at 60 to 84 kg. per sq. cm.; English practice at Vickers-Armstrong works and American practice at Midval Co. Works.

Electric. Electrically-Heated Boilers. Engineering (Lond.), vol. 127, no. 3286, Jan. 4, 1929, pp. 30–32, 8 figs. Systems of electric heating are discussed, and boilers constructed by Sulzer Brothers, Switzerland, described; Sulzer high-voltage electrode system consists of electrode, completely immersed in water, and surrounded by movable insulating tube, so-called evaporating tube; at any position of regulating device, evaporating tube is completely immersed in water.

Feedwater Circuits. Modern Feed-Water Circuits, J. G. Weir. Engineer (Lond.), vol. 147, no. 3811, Jan. 25, 1929, pp. 106–108, 22 figs. Importance of considering feed circuit in detail to establish proper heat balance of installation and to choose best among various circuits available; among factors entering into consideration of best feed circuit are steam pressure, type of boiler, load factor and quality of water available; characteristics of circuits can be studied by means of conventional diagrams; arrangement of boilers in series at varying datum is alternative to incorporating single high-pressure boiler with air preheater, economizer and multiple-stage feedwater heating.

Heat Balance. Heat Balance of Boilers and Its Interpretation (Le bilan thermique des chaudières et son interprétation), G. Beaufaux. Union des Ingénieurs Sortis des Écoles Spéciales de Louvain—Bul. (Louvain), vol. 55, Nov. 15, 1928, pp. 3–64, 5 figs. Necessary steps for obtaining heat balance; loss by incomplete combustion and reasons for it; hand firing; mechanical grates; pulverized coal; losses in smoke and coal in ash for different methods of firing.

Settings. Boiler Framework of the Gersteinwerke Station at Dortmund (Germany) [Le batiment des chaudières de la centrale Gersteinwerk, à Dortmund (Allemagne)]. Génie Civil (Paris), vol. 94, no. 3, Jan. 19, 1929, pp. 66–67, 5 figs. Description of erection of framework for boilers at central power plant at Dortmund, made of structural steel.

Water-Tube, High-Pressure. A 600 Lb. Pressure Water-Tube Boiler for Industrial Use. Engineer (Lond.), vol. 117, no. 3810, Jan. 18, 1929, p. 82, 1 fig. Account of one of two high-pressure boilers for Castner-Kellner Alkali Co. which have recently been supplied and set to work by Yarrow and Co.; boilers are among largest, if not largest, high-pressure boiler plants of this capacity now in commercial operation in England.

Water-Tube, Yarrow. A Modern British Boiler Installation. Power Plant Eng., vol. 33, no. 2, Jan. 15, 1929, p. 138. Description of two Yarrow water-tube boilers, installed at Bankside power station in London; boilers are of double-flow type; economizer, which is of Green cast-iron horizontal tri-tube type is arranged in two banks, one at front and other at rear of steam drum; Yarrow tubular-type air heater mounted above economizer is designed for gases to pass vertically through its tubes, air for furnace passing horizontally round outside of tubes.

C

CALORIMETERS

Bomb, New Type. The Calorific Value of Coal. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 7, Jan. 1929, pp. 366, 368, 370 and 376, 3 figs. Advantages of bomb calorimeter are discussed; disadvantages center very largely on trouble of having to use oxygen in cylinders; as result of nearly 30 years' experience Parr has evolved new type which is a closed-bomb calorimeter with all refinement of oxygen bomb type but having oxygen supplied by means of sodium peroxide first mixed with coal and ignition obtained by means of small length of wire dipping into crucible and heated white hot by passage of electric current from outside.

CAR DUMPERS

Rotary. A Rotary Truck Tippler. Engineer (Lond.), vol. 146, no. 3807, Dec. 28, 1928, pp. 720–721, 6 figs. Tippler made by Strachan and Henshaw, Whitehall Ironworks, has been installed in number of gas works and electricity stations; cage consists essentially of two rings, built up of steel channel bent into circular form, with flanges projecting outwards, and suitably stiffened with plates, angles, etc.; sufficient adhesion is obtained by mounting rings almost centrally over driven rollers, thus obtaining nearly whole weight of rings and car for tractive purposes; inside cage is mounted on L-shaped cradle; driving motor is 12 b.hp. and totally enclosed.

CASE-HARDENING

Cyanide Bath. Salt Bath Hardening. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, p. 16. New flux for rapid and deep carburizing known as Durferrit hardening flux, is described; by addition of various ingredients to sodium cyanide Deutsche Gold- und Silber-Scheideanstalt, of Frankfort-on-Main, have flux evolved by means of which satisfactory case up to 1 mm. depth can be obtained; good finish of work after treatment; absence of distortion claimed.

Distortion in. Distortion in Case-Hardening, M. R. Barat. Metallurgist (Supp. to Engineer, Lond.), Dec. 28, 1928, pp. 181–182. Trouble due to distortion during case-hardening and quenching is capable of more satisfactory treatment than by subsequent rectification; author suggests that it may be possible to predict and calculate amount and nature of distortion likely to occur and to provide for it, to very great extent, by changing size and shape of object as produced prior to cementation; causes of distortion. Abstract translated from Revue de Métallurgie, Oct. 1928.

Ferroalloys. Depth and Character of Case Induced by Mixtures of Ferro-Alloys With Carburizing Compounds, E. G. Mahin and R. C. Spencer. Am. Soc. Steel Treating—Trans., vol. 15, no. 1, Jan. 1929, pp. 117–141 and (discussion) 141–144, 14 figs. Experiments described show that if silicon adsorption is confined to surface layers of iron or steel, carbon absorption during case carburization may be retarded without materially affecting rate of inward migration of carbon after it has been absorbed; by utilizing this principle it is possible to produce deep case without zone of free cementite by using ordinary carburizer in conjunction with ferrosilicon.

[See also NITRIDATION.]

CAST IRON

Arc Welding of. Metallic Electrodes for Cast-Iron Arc Welding, S. Satoh. Am. Inst. Min. and Met. Engrs.—Tech. Publication, no. 162, Jan. 1929, 16 pp., 29 figs. Writer has been able to obtain series of cast irons, from gray to white, without using cast-iron electrodes but by coating on wrought-iron bars mixtures of carborundum and graphite; practical application of cast-iron welding. Bibliograph.

Increasing the Strength of. Chemical and Mechanical Methods to Make Cast Iron Stronger, A. L. Norbury. Iron Age, vol. 123, no. 4, Jan. 24, 1929, p. 268. Discussion of metallurgical principles underlying claims put forward in recently patented methods of producing improved cast iron for better mechanical properties; object has been to reduce percentage of graphite present or to reduce size of flake; preheating mold in various ways; addition of silicides suggested. Paper presented before Manchester Met. Soc.

Machinability. Present Knowledge of Machinability of Cast Iron (Der heutige Stand der Kenntnis von der Bearbeitbarkeit des Gusseisens), A. Wallichs and K. Krekeler. Giesserei (Duesseldorf), vol. 15, no. 52, Dec. 28, 1928, pp. 1289–1292, 5 figs. Methods heretofore in use for testing machinability; determination of cutting speed, taking into consideration depth of cut and feed with workpiece subjected to one-hour test; this method was found most satisfactory and results previously obtained were evaluated on this basis; it is shown that, especially for cast iron, considerable research is still necessary.

CHAINS

Annealing. Service Annealing of Sling and Crane Chains, W. J. Merten. Am. Soc. Steel Treating—Trans., vol. 15, no. 2, Feb. 1929, pp. 193–209 and (discussion) 209–216, 21 figs. Inconsistent results in ductility and strength are ordinarily obtained when chains are annealed at temperatures unsuited for links that have been severely deformed and cold worked in service; author recommends uniform recrystallization at temperatures considerably above transformation range, calculation of permissible stresses based on average cross-sectional dimensions only.

COAL

Low-Temperature Carbonization. Low-Temperature Carbonization of Coal, S. W. Parr. Indus. and Eng. Chem., vol. 21, no. 2, Feb. 1929, pp. 164–168, 12 figs. Author briefly reviews behavior, especially of chemical sort, in two carbonization zones with temperature cleavage line drawn closely along zone of 450 to 500 deg. cent., products of low-temperature zone; mid-temperature coking. Read before Int. Conference on Bituminous Coal.

COLUMNS, STEEL

Machine for Fabricating. Builds Machine for Fabricating Columns, F. B. Pletcher. Iron Trade Rev., vol. 84, no. 4, Jan. 24, 1929, pp. 253–256, 7 figs. See also Iron Age, vol. 123, no. 4, Jan. 24, 1929, pp. 280–282, 5 figs. Details of machine for use in assembling and drilling columns up to 40 in. wide, and also in fabricating beam sections and girder flanges; development of Structural Steel Co.; five men required to operate machine; 75-ft. assembling table with three drilling heads at one end; elements, clamped together under pressure, pass through heads drilling and riveting up to 96 holes every 2 ft.

CONVEYORS

Speed Reducers for. Selection of Speed Reducers for Conveyors, C. E. Broome. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, Jan. 1929, pp. 57–59 and (discussion) 59–60, 5 figs. Conveyors operate at such slow speeds that great reduction in speed is needed between driving motor and head sprocket of conveyor; single or double gear reductions are suitable for small reductions, bevel and worm gears turn right angles, and concentric-shaft type gives great reduction in compact unit; standardization and adaptability; availability for various uses; lubrication and purchasing data.

Unloading. Unloading Conveyor Saves Space and Money, E. J. Tournier. Mill and Factory Illustrated, vol. 3, no. 1, Jan. 1929, pp. 91–92 and 94, 4 figs. Description of recent development in conveyor design which not only accomplishes same purpose as track hopper and elevator, but also unloads cars without use of hopper and requires about 4 ft. less distance between track and building line; conveyor is best used in con-

junction with specially designed bin whose roof serves as support for upper end of conveyor; principal features of drag-chain scoop conveyor.

CRANES

Manufacture, Arc Welding in. Electric Arc Welding in Production Work, F. L. Schlick. Machy. (N. Y.), vol. 35, no. 5, Jan. 1929, pp. 350–352, 7 figs. Description of methods used in making crane trolleys by welding an analysis of costs involved; advantages of arc welding hoist frames; comparative costs of welded steel and cast-iron frames; rolled steel welded to steel casting; running tests for welded gear cages; cost of arc welding; welding strengthening ribs to steel plate.

CRYSTALS

Mechanical Properties of. Molecular Theory Applied to the Study of the Strength Properties of Metal Grain (Die molekulartheoretischen Grundlagen der Festigkeitseigenschaften des Werkstoffkornes), A. Smekal. Stahl und Eisen (Duesseldorf), vol. 49, no. 1, Jan. 3, 1929, p. 21. Construction materials and single crystals; properties of crystals and lattice theory of crystal structure; mechanical properties of ideal and real crystals; photoelectric demonstrations of crystal structure and effect of crystal structure on elastic properties; causes of plasticity and other properties of real crystals. Abstracted from V.D.I. Zeit. (Berlin), May 19, 1928.

CUTTING TOOLS

Design. Machine Tool Design and the New Cutting Alloys. Am. Mach., vol. 70, no. 1, Jan. 3, 1929, pp. 1–2. Survey made by editors of magazine to determine effect of introduction of new tungsten-carbide cutting alloys and other cutting materials; need for design of tool holders; tool dressing will be far different from average operation now; ability of new materials to cut abrasive non-metallic substances; loading time must be reduced; cost as yet unknown.

Sharpening. Effect of Grinding On Hardness and Capacity of Cutting Tools (Der Einfluss des Schleifens auf die Haerte und Leistung von Schneidwerkzeugen), N. N. Sawin. Werkstattstechnik (Berlin), vol. 22, no. 24, Dec. 15, 1928, pp. 688–692, 6 figs. Detailed account of experimental study; rules for sharpening of small tools.

D

DIES

Forging, Manufacture of. The Manufacture of Die Blocks, J. A. Succop. Heat Treating and Forging, vol. 15, no. 1, Jan. 1929, pp. 51–54, 4 figs. Making of die blocks is traced from open-hearth charge to heat-treated and tested product; steel is made in two 18-ton acid open-hearth furnaces; acid process is used; forging and heat-treating practice; factors in proper heat treatment of die blocks; proper heat-treating temperatures, uniformity of temperature and time on temperature; since hardening cracks are occasionally formed, die is subjected to ringing test; chemical composition and physical properties.

Forming, Design of. Making Irregular-Shaped Flanged Cylinders, L. L. Haas. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 438–440, 5 figs. Design of equipment developed for producing long oval-shaped sheet-steel cylinders in quantities of about 2000 per day; dies for forming flanges and trimming them described; fixture for holding flanged cylinders while welding joint.

DIESEL ENGINES

Airless-Injection. Archaouloff Solid Injection System for Diesel Engines, A. J. Diakoff. Power, vol. 69, no. 4, Jan. 22, 1929, p. 125, 1 fig. System has no cam-driven pump, is mechanically independent of engine and does not require any reversing devices; it is operated by means of pneumatic amplifying displacer which is actuated by pressure in cylinder of engine; knocks are eliminated and operation of system is absolutely noiseless; how pump works.

Automotive. Application of Diesel Engines to Automobiles (L'application des moteurs Diesel à l'automobile), M. Seiliger. Technique Moderne (Paris), vol. 21, no. 1, Jan. 1, 1929, pp. 17–19, 10 figs. Description of Maybach 6-cylinder engine, also other engines using direct fuel injection; results of test on Dorner engine.

Starting. Starting of Diesel Engines (Die einwandfreie Imbetriebsetzung der Dieselmaschine), J. Schwarzboeck. Waerme (Berlin), vol. 52, no. 1, Jan. 5, 1929, pp. 7–8, 1 fig. Notes on correct and incorrect method of starting engine; disadvantages and hazards of incorrect starting; method of safe starting in case of defect in starting valve.

E

ELECTRIC FURNACES

Annealing. Electric Annealing Furnaces (Der elektrische Temperofen), F. Russ. Giesserei (Duesseldorf), vol. 16, no. 3, Jan. 18, 1929, pp. 61–62, 3 figs. Advantages of electric annealing are set forth, and two types of furnaces are recommended; special electric furnace is described which is equipped with hood and has annular muffle with heating elements arranged along walls; results obtained with this furnace are given.

ELECTRIC MACHINERY

Welding. Fabrication of Large Rotating Machinery by Welding, H. V. Putnam. Am. Mach., vol. 70, no. 6, Feb. 7, 1929, pp. 250–251. Problems connected with change in policy of Westinghouse Electric and Mfg. Co. to apply fabricated steel in place of castings in construction of larger rotating machinery; engineering departments faced problem of redesigning many lines of machinery; new equipment installed; new operators trained for arc welding; reasons why fabricated steel is justified. Abstract of paper presented before Western Metals Congress.

ELEVATORS

Wire Rope for. Wire Ropes for Elevator Service, F. A. Annett. Power, vol. 69, no. 7, Feb. 12, 1929, pp. 277–278, 3 figs. It is important that proper ropes be selected for elevator and that conditions be right under which they are installed and maintained; when ordering ropes specifications should include: number of pieces and length of each piece, diameter-type of construction and lay, grade and class of service for which it will be used.

F

FLOW OF FLUIDS

Measurement. Electrical Instruments Used in the Measurement of Flow, W. H. Pratt. Am. Inst. Elec. Engrs.—Jl., vol. 48, no. 2, Feb. 1929, pp. 142–146, 4 figs. Paper outlines some important flow-measurement problems and points out character of electric apparatus that may be used with other equipment for measuring flow.

FLOW OF LIQUIDS

Measurement. Application of the Bernoulli Formula to Liquid Flow (Note sur l'application de la formule de Bernoulli aux courants liquides), F. Campus and A. Schlag. Houille Blanche (Lyon), vol. 27, no. 141–142, Sept.-Oct. 1928, pp. 142–143. Application of Bernoulli formula to whole of liquid mass in movement; demonstration of quantity of movement and analysis F. Campus and A. Schlag. Houille Blanche (Lyon), vol. 27, no. 141–142, Sept.-Oct. 1928, pp. 142–143. Application of Bernoulli formula to whole of liquid mass in movement; demonstration of quantity of movement and analysis of speeds and pressures.

Pipes. Measurement of Pipe Flow by the Coordinate Method, F. W. Greve. Purdue Univ. Eng. Experiment Station—Bul., vol. 12, no. 5, Aug. 1928, 31 pp. Investigation described was conducted in hydraulic laboratory of Purdue University to determine (1) empirical relation between rate of discharge from horizontal pipe and coordinates of upper surface of issuing stream; (2) relation between actual mean velocity within pipe to that indicated by law of freely falling body in vacuo as applied to upper surface of jet; and (3) possibilities and limitations of method.

FORM-TURNING MACHINES

Proportional. Proportional Form-turning Machine. Machy. (Lond.), vol. 33, no. 847, Jan. 3, 1929, pp. 454–455, 3 figs. Details of form turning machine employed in production of wooden shoe lasts; machine can be set to turn shoe lasts of same size and shape as master model or, by adjustment of proportional mechanical movement mechanism, it can be made to form lasts longer or shorter than model as well as thicker or thinner; machine can be adjusted for turning left or right-foot lasts from same model.

FOUNDRIES

Electric Trucks in. The Electric Truck in the Foundry, H. J. Dorus and C. S. Schroder. Can. Machy. (Toronto), vol. 39, no. 26, Dec. 27, 1928, pp. 224, 226, 229, 230, 236 and 239, 12 figs. Operation of industrial electric truck in typical small foundry; factors in computing return on investment in materials handling equipment; information given to show how cost of materials handling in foundries can be reduced; cost of maintenance; moving raw material; charging cupola; carrying molten metal, cores, sand, foundry refuse, finished mold and castings; special purposes truck; charging annealing furnaces; aids to shipping.

FURNACES, ANNEALING

Continuous. Construction and Operation of Kathner Normalizing Furnaces, C. P. Mills. Eng. Soc. West. Pa.—Proc., vol. 44, no. 9, Dec. 1928, pp. 305–321 and (discussion) 322–329, 15 figs. System whereby bottom, side walls and roof are completely insulated; furnaces are divided into two main sections, heating zone and cooling zone; two independent sets of burners are necessary so as to permit use of oil at time when natural gas is not available; conveying mechanism used throughout furnace; sectional type of construction used in this furnace; automatic temperature-control equipment; operating furnace of this type.

FURNACES, HEAT-TREATING

Design. Heat-Treating Furnace Design, J. H. Gumz. Am. Mach., vol. 70, no. 6, Feb. 7, 1929, p. 250. Questions involved in design of heat-treating furnaces discussed; in plants having limited number of variety of parts to be heat-treated, batch-type furnace is usually satisfactory; annealing, hardening and drawing furnacer should be so fired that there is little or no danger of flame coming in contact with material being heat-treated; muffle furnaces; uniformity of heat most important in salt baths. Abstract of paper presented before Western Metals Congress.

FURNACES, HEATING

Pusher-Type. Fuel Combustion in Pusher-Type Furnace (Comsommation de combustible dans les fours poussants), M. Laffargue. Chaleur et Industrie (Paris), vol. 9, no. 103, 1928, pp. 379–382 and (discussion) 382–383. Increase in use of this type of furnace is due to higher flame temperatures in furnace head; these temperatures are obtained by elevated combustion temperature and by concentration of flame.

FURNACES, MELTING

Pulverized Coal. "Brackelsberg" Pulverized-Coal-Fired Rotary Furnace, for Melting Gray and Malleable Iron (Le four rotatif "Brakelsberg" au charbon pulvérisé pour la fusion de la fonte grisé et de la fonte malleable). Fonderie Moderne (Paris), vol. 23, Jan. 10, 1929, pp. 4–6. Description of furnace and its operation and advantages; capacity 6 tons, 5 m. long and 1.2 m. inside diam.

G

GAS ENGINES

Combustion. Combustion in Engine Cylinders (Zur frage der Verbrennung im Maschinenzylinder), W. Wagner. Waerme (Berlin), vol. 52, no. 2, Jan. 12, 1929, pp. 22–23, 5 figs. Combustion phenomena are investigated, based on analysis of gas specimens from cylinder of blast-furnace-gas engines.

Scavenging and Supercharging in High-Power Gas Engines (Le balayage et la suralimentation dans les moteurs à gaz à grande puissance), J. Brunswick. Technique Moderne (Paris), vol. 21, no. 1, Jan. 1, 1929, pp. 7–10, 6 figs. Description of new arrangement for easily increasing power of gas engines and its application to engines used in blast furnaces; engines with and without scavenging; valve mechanism, regulation.

GAS PRODUCERS

Design. Reaction and Flow Phenomena in Gas Producers as Basis for Design (Die Reaktions- und Stroemungsvorgaenge in Generatoren als Grundlage fuer deren konstruktive Durchbildung), E. Terres. Gas- und Wasserfach (Munich), vol. 71, no. 50, Dec. 15, 1928, pp. 1205–1213, 16 figs. Study of factors influencing composition of producer gas and efficiency of gas producers, construction of Terres-Didier gas producer.

GEAR CUTTING

Chamfering Machines. Gear Tooth Chamfering. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, p. 33, 1 fig. Details of Lipe gear tooth chamfering machine in which new method of tooth rounding is employed; machine consists essentially of direct-driven cutter spindle and adjustable work head with spindle which may be indexed automatically by means of variable throw-crank disk.

Gear-Shaving Process. The Pratt & Whit-

ney Gear-Shaving Process, H. D. Tanner. Machine-Shop Practice (A.S.M.E. Trans.), vol. 50, no. 27, Sept.-Dec. 1928, pp. 17–22 including discussion, 22 figs. Practical method of generating involute spur or helical gears at zero degrees which was invented by J. H. Barnes, Dayton, Ohio; active profiles of gear teeth generated by rolling gear in mesh with zero-degree rack; active profiles of this rack are top edges of its teeth, which coincide with cutting edges of tools; tools with straight cutting edges slightly longer than face of gear to be cut.

GEARS

Design. Formula for Worm and Spiral Gear Train, W. E. Trask. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 453–454, 1 fig. Method of obtaining required dimensions when regular worm is designed to run with spiral gear; problem of designing worm hinges on calculation of helix or spiral angle; designing worm and spiral gear of even normal diametral pitch when ratio required is given with normal diametral pitch, approximate outside diameter of worm, and center distance.

Reduction. High-Speed Gearing, I. Short. Machine-Shop Practice (A.S.M.E. Trans.), vol. 50, no. 27, Sept.-Dec. 1928, pp. 5–14 including discussion, 33 figs. Some of requirements of high-speed reduction gears and how they are attained commercially; reduction gears furnished by Westinghouse Electric and Mfg. Co. action of gears; wear of gear teeth; wear due to pitting; allowable loading of teeth; importance of correct alignment; lubrication of teeth; noise in gears and its elimination; analysis of gear noise; typical gears.

Tooth Wear. Dispelling the Mystery of Gear-Tooth Breakage, Wear and Noise, A. B. Cox. Soc. Automotive Engrs.—Jl., vol. 24, no. 1, Jan. 1929, pp. 67–72, 7 figs. From outline of accumulated evidence of theory and experiment given, it is concluded that integral contact gearing is solution of most baffling problems of gear-tooth fatigue and breakage, wear and pitting, vibration and noise; comparison with other gearing, it is particularly suitable for automobile transmissions and timing gears, and for replacing spiral-bevel drive gears with straight bevel gears.

GUNS

Machining. Machining the Breech Mechanisms of Large Guns. Machy. (Lond.), vol. 33, no. 849, Jan. 17, 1929, pp. 501–504, 10 figs. Details of machine-shop operations of unusual interest performed at Watervliet Arsenal; cutting threads of breech blocks and bushings; producing swing clearance in breech busings; machining slots between threads of breech blocks; milling spiral teeth on breech blocks.

H

HARDNESS TESTING

Cloudburst Process. Cloudburst Process of Hardness Testing, E. G. Herbert. Iron Age, vol. 123, no. 2, Jan. 10, 1929, pp. 145. Cloudburst process is described; by this means exact shape and location of soft areas may be determined; how machines handle work; producing work hardened surface; four principal functions of cloudburst process of bombardment by steel balls. Brief abstract of paper presented before Am. Soc. Steel Treating.

HEAT TRANSMISSION

Convection. Transmission of Heat by Convection in Industrial Equipment (De la transmission de la chaleur par convection dans les appareils industriels), A. Léveque. Chaleur et Industrie (Paris), vol. 9, no. 103, Nov. 1928, pp. 397–409 and (discussion) 409–412, 9 figs. Actual knowledge of laws of heat exchange by convection is discussed; heat transmission in cylindrical tubes; heat transmission of hot gases in boiler-tube nests; problem of recooling latent fuel; heat exchange between condensing steam tubes of surface condensers.

Pipes. Researches in Heat Transmission (Untersuchungen zum Waermeuebergangsproblem), L. Schiller. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 8, no. 6, Dec. 1928, pp. 453–454. Paper read at 1928 meeting of German Society for Applied Mathematics and Mechanics; general discussion and note on author's experiments dealing with the transfer of heat from gas flowing through pipe to pipe shell.

Tests to Determine Heat-Transmission Coefficient of Air und Flue Gas in Pipes (Versuch zuer Bestimmung der Waermeuebergangszahl von Luft und Rauchgas in technischen Rohren), E. Schulze. Stahl u. Eisen (Duesseldorf), vol. 48, no. 51, Dec. 20, 1928, pp. 1777–1782, 4 figs. Influence of gas velocity, pipe diameter, and length; influence of temperature and of differences between temperature of gas and wall; influence of pressure; results of tests. Abstract of reports published in full in Archiv fuer das Eisenhuettenwesen, Oct. 1928.

Walls, Resistance to. Synthetic Rules on the Transmission of Heat, A. Sellerio. Information on Refrigeration (Institut International du Froid)—Bul., vol. 9, no. 4, July-Aug. 1928, pp. 634–636. Note concerning article of E. Praetorius, published in Archiv. fuer Waermewirtschaft, 1926. Author considers that conductivity in ordinary cases of transmission through compound walls is inconvenient for purposes of calculation, and suggests substitution of resistance of it; formulas are simpler, more intuitive from physical standpoint, and clearer for their comparison with those of electro-technology. From Industria, Sept. 30, 1926, p. 478.

HONING

Finishing Bores by. Finishing Bores by Honing. Machy. (Lond.), vol. 33, no. 847, Jan. 3, 1929, p. 436. Practice of honing now widely used for finishing automobile-engine cylinder bores and Diesel, gas-engine, and air-compressor cylinders is discussed; peripheral speed of 200 to 250 ft. per min.; reciprocating speed of 50 to 60 cycles; present practice is to employ stones 4 in. long, $\frac{1}{2}$-in. wide, and $\frac{1}{8}$ in. thick; purpose of honing is to straighten inequalities of bore; tendency to employ honing more and more as stock-removing process.

HYDRAULIC TURBINES

Design. Progress in Hydraulic-Turbine Design. Kaplan and Propeller Turbines (Fortschritte im Bau von Wasserturbinen, Kaplan und Propellerturbinen), Oesterien. V.D.I.-Zeit. (Berlin), vol. 72, no. 50, Dec. 15, 1928, pp. 1831–1841, 27 figs. Transition from Francis type to propeller and Kaplan types; conical turbines; construction details and characteristics of adjustable blades, their effect on efficiency; limits of high pressure, permissible elevation above tailwater level; economic considerations.

Governors. New Governor for Hydraulic Turbines (Nuovo regolatore autocompensato per motori idraulici), A. Calzoni. Elettrotecnica (Milano), vol. 15, no. 26, Sept. 15, 1928, pp. 713–716, 8 figs. Various governors by Escher, Wyss and Voith are described and illustrated, types being of rigid and semi-rigid compensation kinds; details are given of author's own self-compensating device in mechanism of which, on rotating plate in middle of disk, band running on pulley drives spiral shaft and turns its nut with the same velocity as that of shaft when on middle of disk rotation corresponding with regular water flow.

Regulation of Kaplan Turbines (Sur le réglage des turbines Kaplan). Bul. Technique de la Suisse Romande (Paris), vol. 54, no. 26, Dec. 29, 1928, p. 310. Description of apparatus for regulation of Kaplan turbines by Voith.

Lilla Edet Plant. Power Equipment of the Lilla Edet Hydroelectric Plant (Die Maschinenanlage des Kraftwerkes Lilla Edet), A. Ekwall and H. Munding. V.D.I.-Zeit (Berlin), vol. 72, no. 51, Dec. 12, 1928, pp. 1873–1880, 22 figs. Details of high-speed hydraulic turbines of Kaplan and Lawaczeck designs; turbine speed regulators and other appurtenances; description of 10,000-kw. direct-coupled generators; tests and actual performance; comparison of tests of turbine models together with results of acceptance tests.

I

INDUSTRIAL MANAGEMENT

Principles. To Secure Industrial Peace—Managerial Efficiency in its Broadcast Sense must Be Developed to Abolish Class Consciousness and to Encourage Interdepartment Cooperation, S. A. Lewisohn. Eng. and Min. Jl., vol. 127, no. 4, Jan. 26, 1929, pp. 152–156. Capital and labor are likened to elements in family life; when older brothers mistreat and exploit younger brothers, latter indulge in fantasies of revenge, while former are overcome by sense of guilt and fear; factory production sometimes proceeds as if conducted by two embattled armies during temporary armistice; stresses advantage of close study of management problems and training of foreman. Address before American Committee of Geneva Inst. of Int. Relations.

Production Planning. Production Planning. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, pp. 15–16, 5 figs. Simplified procedure for application to factories of moderate size; shops had to be planned to ensure capacity for given number of units per week; weekly production schedule described; system of progress cards, operation work orders, and stock record outlined.

Time Study. Time Study and Works Analysis (Zeitstudie und Betriebsanalyse), V. Polak. Archiv. fuer das Eisenhuettenwesen (Duesseldorf), vol. 2, no. 7, Jan. 1929, pp. 457–460, 12 figs. Comparison between systematic method of applying time studies and system of making casual time studies as occasion arises; practical examples of latter method are given, from which conclusions are drawn for improvement of plant operation.

INDUSTRIAL PLANTS

Dust Removal. Modern Pneumatic Dust-Removal Systems. Mech. World (Manchester), vol. 85, no. 2192, Jan. 4, 1929, pp. 5–6, 2 figs. Ideal to be aimed at when arranging pneumatic dust-removal system is to preserve shortest total lengths of duct work, while at same time keeping branches evenly balanced; in exhaust systems velocities at farthest branches from fan usually range from 3000 ft. to 4000 ft. per min. for dust from sand-blast, and wood-sanding machines; about 3500 ft. to 4500 ft. per min. for chips and sawdust.

INDUSTRIAL TRUCKS

Electric. Electric Trucks in Iron and Steel Plants (Elektrokarren in Eisen und Stahlwerken), G. Lucas. Stahl und Eisen (Duesseldorf), vol. 49, no. 3, Jan. 17, 1929, pp. 84–85, 6 figs. Description of different types of electric trucks and trailers, supplied by Allgemeine Elektrizitaets-gesellschaft (A.E.G.) and Siemens-Schuckert Werke, S.S.W., including hopper cars, platform trucks, personnel-carrying trucks, etc., suitable for use in blast-furnace plants and rolling mills.

[See also FOUNDRIES, Electric Trucks in.]

INTERNAL-COMBUSTION ENGINES

Double-Acting. Double-Acting High-Speed Internal-Combustion Engine. Engineering (Lond.), vol. 126, no. 3285, Dec. 28, 1928, pp. 805–807, 12 figs. Particulars of Biga engine, made by E. G. Hohe, Hamburg, in which double-ended piston of crosshead type is employed; point of great importance is that of weight of reciprocating masses; suitability of Biga engine for more extensive adoption of 2-stroke cycle especially for engines consuming heavier hydrocarbons, is pointed out.

Efficiency. Increase in Efficiency in Explosion Engines by Utilization of Prolonged Expansion (L'augmentation du rendement dans les moteurs à explosion par l'utilisation de la détente prolongée), M. Mathieu. Arts et Métiérs (Paris), vol. 81, no. 99, Dec. 1928, pp. 445–449, 3 figs. Definitions and notations; theoretical thermal efficiency; what is gained by prolonged expansion.

Single-Sleeve-Valve. The Single Sleeve Valve Engine, A. Fales. Tech. Eng. News, vol. 9, no. 8, Jan. 1929, pp. 330–331, 7 figs. Developed at Massachusetts Institute of Technology, it holds promise of many improvements over motors of conventional design; conventional design in construction of crankshaft, connecting rods and pistons; difference in construction is in cylinder block and heads, sleeve valves, and sleeve-operating mechanism; engine has 6 cylinders with bore of $2^7/_8$ in. and a stroke of $4^3/_4$ in.; compression ratio of 5.4 to 1.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON

Nickel-Chromium. See NICKEL-CHROMIUM IRON.

IRON CASTINGS

Shrinkage Holes. Shrinkage Holes in Small Grey Iron Castings, P. A. Russell. Foundry Trade Jl. (Lond.), vol. 40, no. 647, Jan. 10, 1929, pp. 27–28 and 37. Discussion of paper previously published in journal; rate of cooling and solidity; life of chills; separation of gear-wheel blank troubles; white-iron castings; hot spots and phosphorus.

L

LATHES

Experimental. New Experimental Lathe of the Aachen Machine-Tool Laboratory (Eine neue Versuchsdrehbank des Aachener Werk-

zeugmaschinen-Laboratoriums), K. Krekeler. Stahl und Eisen (Duesseldorf), vol. 48, no. 52, Dec. 27, 1928, pp. 1832–1833, 1 fig. Lathe of medium size was constructed, based on years of experiment, for handling workpieces of average and small size and subjecting them to highest speeds; requirements which received careful attention were drive and speeds, feeds, support, cooling equipment, etc.

Manufacture. Building Lathes on a Production Basis. Am. Mach., vol. 70, no. 4, Jan. 24, 1929, pp. 155–158, 10 figs. Brief description of plant layout and methods employed by Monarch Machine Tool Co., Sidney, Ohio, for manufacturing lathes on production basis; monorail extends from casting receiving platform to assembly floor; number of milling operations; particulars of up-to-date machine-tool equipment.

Wheel. Heavy Duty Railway Wheel Lathe. Engineer (Lond.), vol. 117, no. 3810, Jan. 18, 1929, pp. 78–79, 6 figs. partly on p. 74. New design of motor-driven single-purpose railway-wheel lathe has been produced by Noble and Lund in association with Alfred Herbert, Ltd.; driving motor mounted on baseplate, which is bolted to concrete foundation, transmits its power through gear box, extending from front of bed, on to shaft running longitudinally near floor level.

LIGHTING

Factory. The Economics of Light in Factories. Eng. and Boiler House Rev. (Lond.), vol. 42, no. 7, Jan. 1929, pp. 381 and 386, 1 fig. Brief summary of various characteristics which all good lighting systems should possess, all of which it is claimed are incorporated automatically in system of lighting which employs modern industrial lighting fittings of reputable manufacture, and installed in accordance with manufacturers' recommendations; example of modern industrial lighting is shown.

LOCOMOTIVES

Diesel. Crude-Oil Engine Locomotive. Engineering (Lond.), vol. 127, no. 3287, Jan. 11, 1929, pp. 45–46, 9 figs. partly on pp. 43–44. Locomotive constructed by Kerr, Stuart & Co., has engine of Diesel type which actuates driving wheels by mechanical transmission, through gear box and clutches, and is started by small gasoline-driven engine; this latter turns crankshaft and is automatically cut out when Diesel engine commences to fire regularly; locomotive is fitted with 60 b.hp. McLaren Diesel engine with four cylinders; it is water cooled, radiator being situated in driver's cab.

Diesel-Electric. Diesel-Electric Main-Line Locomotive of 2660 Hp. Oil Engine Power, vol. 7, no. 1, Jan. 1929, pp. 40–43, 3 figs. Details of 2660-hp. oil electric locomotive of Canadian National Railways; two units, each having engine-generator set mounted on locomotive frame, boiler equipment for steam heating of passenger coaches, four traction motors, air brake, and other auxiliary equipment; 100,000 lb. tractive effort developed; Beardmore 12-cylinder, 12-in. bore and stroke, oil engine of solid-injection type.

Oil-Electric. Further Developments in Oil Electric Motive Power on Canadian National Railways. Ry. and Locomotive Eng., vol. 41, no. 11, Nov. 1928, pp. 320–322, 3 figs. Locomotive, consisting of two units weigh 650,000 lb.; each unit consists of oil-engine generator set mounted on locomotive frame, boiler equipment for steam heating of passenger coaches, four traction motors for propelling locomotive, air brake, etc.; Beardmore-cylinder oil engine of solid-injection type, 12-in. bore and 12-in. stroke giving 1330 hp. at 800 r.p.m.; the exhaust gases of the engine are conducted to an economizing boiler.

Powerful Oil-Electric Locomotive for Canadian National. Ry. Elec. Engr., vol. 20, no. 1, Jan. 1929, pp. 18–20, 3 figs. Locomotive, consisting of two units, weighs 650,000 lb. when fully equipped, of which 480,000 lb. is carried on driving wheels; traction motors gears to driving axles; each unit contains Beardmore 12-cylinder oil engine of solid-injection type, 12-in bore and 12-in. stroke; nominal rating is 1330 hp. at 800 r.p.m.; exhaust heat aids oil-fired boiler to heat train; oil-fired boiler installed in each unit; electrical control apparatus; mechanical design.

LUBRICATION

Machinery of. The Machinery of Modern Lubrication, E. Caldwell. Indus. Power, vol. 11, no. 2, Feb. 1929, pp. 65–68, 136, 138, 140 and 142, 6 figs. Automatic circulating, oiling, and filtering systems now used for engines, compressors, ice machines, gas engines, turbines, and for most classes of steel-mill, paper-mill, and other industrial machinery; modern systems change oil automatically.

M

MACHINE DESIGN

Instruments and Apparatus. Principles of Instrument and Apparatus Design (Konstruktionsgrundlagen der feinmechanischen Technik), W. Kniehahn. V.D.I. Zeit. (Berlin), vol. 72, no. 49, Dec. 8, 1928, pp. 1773–1775, 34 figs. Discussion of standard structural elements, joints, bearings, gearing, etc., of mechanical, electric, optical, and acoustic apparatus.

MACHINE TOOLS

Arc Welding. Arc-Welded Steel Construction in the Machine Tool Industry, A. F. Davis. Am. Mach., vol. 70, no. 5, Jan. 31, 1929, pp. 211–214, 8 figs. Discussion of what is being done in way of redesigning machine tools for better and more economical construction; substitution of steel for cast iron for larger units; most of machine tools with welded steel construction are of type subjected to severe strain; by means of arc welding it is possible to build up structures even more intricate than can be cast; several examples of arc-welded machine tools.

Cost Reduction in Manufacture. Manufacturing Economies Effected in Machine Tool Plants, E. F. DuBrul. Iron Age, vol. 123, no. 1, Jan. 3, 1929, p. 50. Efforts toward cost reduction undertaken in machine-tool industry are discussed; better utilization of facilities already available; installation of improved facilities; reduction of costs by eliminating unnecessary sizes; reduction of costs through standardization of parts and components; 1928 expenditure on further standardization will also pay good dividend on its cost.

Cutting Speeds. Correct Cutting Speeds Important for Modern Machine Tools. Iron Trade Rev., vol. 84, no. 3, Jan. 17, 1929, p. 198. In many cases cutting speeds could be increased by speeding up each line of shafting; tendency in modern designs of machine tools is to fit them with pulleys too small to take full advantage of modern steels; improvements suggested for lathes and boring mills, and for leather belts. Abstract from Dec. 1928, issue of Edgar Allen News, published by Edgar Allen & Co., Sheffield, England.

Design. New Cutting Alloys to Revolutionize Machine Tools. Iron Trade Rev., vol. 84, no. 1, Jan. 3, 1929, pp. 24–25, 3 figs. Design of machine tools will be greatly affected by new cutting alloys, experts believe; refinements in anti-friction bearings, and improved lubrication; opinions of leading authorities quoted.

Tool-Block Design. Improvements in Multiple Tool-blocks. Machy. (N. Y.), vol. 35, no. 5, Jan. 1929, pp. 366–369, 6 figs. Important points to consider in designing tool blocks to obtain greatest economy from their use; suggestions for improvements and standardization; good and bad features of common types of multiple blocks; improved form of multiple tool block; multiple tool blocks applied to turrets; standard details for improved tool blocks; improved shoe and stud.

Welded Steel Construction. Steel Construction in Machine Building (Die Stahlbauweise im Maschinenbau), C. Krug. V.D.I. Zeit. (Berlin), vol. 73, no. 1, Jan. 5, 1929, pp. 14–16, 2 figs. Developments of welding technique favors steel as construction material for machine, particularly machine tools; estimate of probable saving in costs; new problems of mechanism and external lines brought about by use of steel; advantages of new method of construction.

MACHINING METHODS

Hole Finishing. The "Pressfinish" Method for Enlarging and Polishing Holes, O. Schlippe. Am. Mach., vol. 69, no. 26, Dec. 27, 1928, pp. 989–991, 7 figs. Report of research on factors influencing finishing of holes by pressing balls through them; comparison of results with other methods of finishing; research, in which balls were forced through 0.787-in. holes, indicates that this method results in high polish, increased hardness, and satisfactory accuracy.

Finishing Holes by Milling. Machy. (Lond.), vol. 33, no. 847, Jan. 3, 1929, pp. 429–434, 12 figs. Method by which several bores of various diameters may be milled at same time that facing or threading cuts are taken on Planetary milling machine built by Hall Planetary Co., Philadelphia; cutters and chucks designed to suit individual job; milling outer races of ball bearings; finishing concave automobile part; taking six and seven cuts simultaneously; milling piston rings in large quantities; machining rear-axle housings; hole and thread milling at same time.

MAGNESIUM-ALLOY CASTINGS

Properties and Advantages. Magnesium Alloy Castings, E. Player. Automobile Engr. (Lond.), vol. 19, no. 250, Jan. 1929, pp. 29–31. Production, properties, and applications of elektron metals; mechanical properties of sand castings and of wrought alloys; strength-weight ratio; foundry practice; molding and core making; die casting. Abstract of paper presented before Birmingham Met. Soc., Staffordshire Iron and Steel Inst., and Birmingham Local Section of Inst. of Metals.

MALLEABLE-IRON CASTINGS

White-Heart. Production of Malleable Castings, F. H. Hurren. Foundry Trade Jl. (Lond.), vol. 40, no. 647, Jan. 10, 1929, pp. 33–34 and (discussion) 34–36. Production is divided into actual production of casting on foundry floor and subsequent heat treatment; consideration of composition and class of iron charged into cupola and feeding and gating of casting; during annealing process, part of total carbon is eliminated and part is changed from combined to free or graphitic state; in discussion, author replies to question concerning setting distorted castings.

MATERIALS HANDLING

Cargoes. Cargo Handling Costs Cut in Half Using Tractors and Trailers. Mar. Rev., vol. 59, no. 2, Feb. 1929, pp. 44–47, 6 figs. Operation of Goodrich Transit Co., exemplifies in highest degree application of important principle of cargo handling, keep freight off floor of dock and deck of ship; average haul is 350 ft.; special trailers with bodies; capital charges on trailers amount to about 5 cents per day.

Industrial Plants. Conveyors Reduce in Process Time. Iron Age, vol. 123, no. 4, Jan. 24, 1929, pp. 272–273, 4 figs. Mechanical handling devices in plant of F. & N. Lawn Mower Co., Richmond, Ind., are described; roller and belt conveyors are used for interdepartment hauls and for loading freight cars.

METALS

Machinability. Machinability, E. G. Herbert. Metallurgist (Supp. to Engineer, Lond.), Jan. 25, 1929, pp. 1–2. Review of paper before Institution of Mechanical Engineers; author studied behavior of series of steels under lathe-cutting conditions, and carried out measurements on hardening effect of cutting operation; it is evident that machinability is much more difficult thing to measure than has hitherto been believed, or even than Herbert's work would, by itself suggest; considerations raised by paper serve to demonstrate importance of work he has done and need for more work of still more comprehensive kind.

Machinability, Drilling Test as Index of. Drilling Test as Index of Machinability of Metals (Der Bohrversuch als Kennzeichen der Bearbeitbarkeit der Metalle), G. Schlesinger and S. Patkay. Werkstattstechnik (Berlin), vol. 22, no. 24, Dec. 15, 1929, pp. 677–683. Symposium of two papers: (1) development of drilling test since 1902; (2) machinability, drilling and twist drills; micro photographs of specimens of steel alloys tested with twist drill.

MICROMETERS

Spindle Testing. Inspection of Micrometer Spindles at the Zeiss Works, H. Simon. Am. Mach., vol. 70, no. 4, Jan. 24, 1929, pp. 175–176, 3 figs. Testing lead of Zeiss micrometer spindle thread to 0.00005 in. by combined linear and angular measurements is described; Zeiss micrometers are guaranteed not to vary more than 0.000125 in. in 1-in. length; details of Zeiss lead-testing machine.

MOTOR TRUCKS

Design. Some Observations on Trends in Modern Truck Practice, H. B. Hall. Power Wagon, vol. 42, no. 249, Jan. 1929, pp. 8–9. Development of motor truck described; truck of future will be confined to 5-ton carrying capacity; trucks of larger carrying capacities will be legislated off highways, if not previously proved uneconomic; truck of future will have steel wheels, either spoke, wire or disk, and will have speed range up to 50 m.p.h.; dual pneumatic tires on rear wheels, or dual axles, have come to stay.

N

NICKEL-CHROMIUM IRON

Properties. Nickel-Chromium Alloy Iron, W. R. Shimer. Am. Mach., vol. 70, no. 6, Feb. 7, 1929, pp. 249–250. Uses and properties of Mayari nickel-chromium iron, especially in automobile manufacture; wear-resisting properties;

results of research; no attempt made to change natural proportions of alloy. Abstract of paper presented before Western Metals Congress.

NITRIDATION

Process, Details of. Nitriding—What It Is, How It Is Done, Properties Obtained, S. F. Cushman, Jr. Am. Mach., vol. 70, no. 5, Jan. 31, 1929, pp. 191–193, 4 figs. Nitriding or surface hardening by action of nitrogen on special steels, is discussed; parts are packed in promoters in gas-tight box, pure ammonia gas admitted, and box and contents heated to about 950 deg. fahr.; outstanding properties of extreme hardness and resistance to wear; tests.

O

OIL ENGINES

Airless Injection. The Doxford Opposed-Piston Oil Engine. Power Engr. (Lond.), vol. 24, no. 274, Jan. 1929, pp. 25–27, 3 figs. New engine has compression pressure of 425 lb. per sq. in. and is started from cold without any preliminary warming-through process; it has 3 working cylinders 15¾ in. diam., and combined stroke of 2 pistons is 51¼ in., designed output of engine being 560 b.hp., at 125 r.p.m.; arrangement of piston cooling gear is shown.

OPEN-HEARTH FURNACES

Lackner Type. Lackner System of Open-Hearth Furnace (Siemens-Martin-Ofen, Bauarf Leckner), G. Mueller. Stahl und Eisen (Duesseldorf), vol. 49, no. 3, Jan. 17, 1929, pp. 79–80, 3 figs. Details of 30-ton furnace with primary and secondary air inlet, supplied by Lackner Furnace Works, Dortmund, to Lovere Steel Works in Brescia, Italy; it differs from usual open-hearth design in fact that air comes twice in contact with gas, effecting perfect combustion of flame at entry into furnace and thus achieving higher efficiency. Abstract translated from Rassegna Mineraria e Metallurgica Italiana, vol. 68, 1928, p. 55.

P

PICKLING MACHINES

Types. Sheet-Pickling Machines, W. Kraemer. Iron and Coal Trades Rev. (Lond.), vol. 117, nos. 3172 and 3173, Dec. 14 and 21, 1928, pp. 865–866 and 906, 9 figs. Dec. 14: Types of machines used; in one, driving engines are combined for shaking and shifting and lowering; in other, sheets are conveyed in trucks to plant and there placed cradles which are handled by traveling crane or crab. Dec. 21: Choice of pickling plant; construction of cradles. Abridged translation from Stahl und Eisen.

PIPE BENDS

Research. Further Research on Pipe Bends, W. Hovgaard. Jl. of Mathematics and Physics, vol. 7, no. 4, Dec. 1928, pp. 239–297, 27 figs. Discussion of stresses and strains in pipe bends; description of tests made at Massachusetts Institute of Technology; analysis of tests comprising curves and tables which facilitate general survey of results; discussion of strength of pipe bends.

PIPE, CAST-IRON

Centrifugal Casting. A Study of Centrifugally-Cast Pipe (Metal-Mold Process) Versus Sand-Cast Pipe, F. N. Menefee and A. E. White. Univ. Mich. Dept. of Eng. Research—Reprint, no. 4, Aug. 1928, pp. 1–31 and (discussion) 32–37, 30 figs. Investigation undertaken at request of Water Board of City of Detroit to determine relative merits of sand-cast pipe and pipe centrifugally cast in metal molds; work involved physical, chemical and metallographic tests; description of methods of manufacture. Read before Am. Soc. Testing Matis.

Hamilton Uses New Electric Foundry Process for Cast Iron Pipe. Elec. News (Toronto), vol. 38, no. 3, Feb. 1, 1929, pp. 44–47, 6 figs. Manufacture of sand-spun cast-iron pressure pipe; process of manufacture, with exception of cupola furnace, is mostly electrical; casting pipe; stripping mold; cleaning pipes; advantages of process; d.c. control.

PLATE-BENDING MACHINES

Thick-Boiler-Plate. New Babcock & Wilcox Plant. Mar. Engr. and Motorship Bldr. (Lond.), vol. 52, no. 616, Jan. 1929, pp. 17–18, 3 figs. Some details of new high-power 8000-ton shell-bending press capable of dealing with 2¼-in. boiler plates up to 40 ft. in length.

PLATES, RECTANGULAR

Vibrations in. Experimental Study of the Ritz Theory of Transverse Vibrations of Square Plates (Experimentelle Untersuchungen zur W. Ritzschen Theorie der Transversalschwingungen quadratischer Platten), A. Lemke. Annalen der Physik (Leipsig), vol. 86, no. 5, July 28, 1928, pp. 717–750. Tables from which coefficients of series and period equation can be calculated are given for several values of Poisson's ratio, 10 terms of series being used; two cases are also given, using 6 and 15 terms, to show what may be expected of approximation to 10.

PULVERIZED COAL

Burners. Todd Pulverized Coal Burners. Pac. Mar. Rev., vol. 26, no. 1, Jan. 1929, pp. 32–33, 1 fig. Tests recently concluded on new type pulverized-coal burners at fuel oil-testing plant at League Island Navy Yard; apparatus which was finally developed and used in tests; capacity of burners; grade of coal burned.

PUMPS, CENTRIFUGAL

Design. Present Status of Centrifugal-Pump Design (Der gegenwaertige Stand des Kreiselpumpenhaues), C. Pfleiderer. V.D.I.-Zeit. (Berlin), vol. 73, no. 4, Jan. 26, 1929, pp. 126–130, 10 figs. Theoretical principles of design of blades; cavitation as function of blade shape, suction, pumping lift, speed, and water temperature; viscosity effect; computed vs. actual pump capacities; types of pump regulation.

R

RAILWAY MOTOR CARS

Gasoline-Electric. De Luxe Motor Train Exhibited. Ry. Age, vol. 86, no. 3, Jan. 19, 1929, pp. 197–198, 3 figs. Three-car gas-electric train; 300-hp. gas-electric plant installed; six-cylinder engine, with 8-in. by 10-in. cylinders develops 300 hp. at 900 r.p.m. burns either gasoline or petroleum distillate; engine is directly connected to electric generator which supplied current to two traction motors mounted on forward truck.

Operation. Motor Cars Handle Cincinnati Northern Passenger Traffic. Ry. Age, vol. 86, no. 4, Jan. 26, 1929, pp. 247–248, 1 fig. Motor cars are combination baggage and mail equipped with Electro-Motive Co. 225-hp. gasoline-electric power plants; cost of operation; inspection and maintenance.

REFRIGERATING MACHINES

Compound. An Ideal Cycle for Cold-Vapor Compound Compression Machines (Zur Festlegung eines Idealprozesses fuer die Kaltdampf-Verbundkompressionsmaschinen), K. Heinze. Zeit. fuer die gesamte Kaelte-Industrie (Berlin), vol. 35, no. 6, June 1928, pp. 113–115, 1 fig. See also translated abstract in Information on Refrigeration (Institut Int. du Froid)—Bul., vol. 9, no. 4, July-Aug. 1928, pp. 618–622. Author suggests to set down as specific refrigerating production, in case of two-stage compression proper, optimum value at most favorable intermediate pressure, which results from ideal cycle with perfect intermediate cooling.

ROLLING MILLS

Cluster. Cluster Mills for Rolling Steel. Iron Age, vol. 123, no. 4, Jan. 24, 1929, p. 285, 1 fig. Discussion of why cluster mills give good service; roller bearings take heavy loads; details of four-high mills and cluster mills; German mill for cold rolling.

Four-High. Power Efficiency in Rolling a Function of the Roll Diameter, L. Weiss. Rolling Mill Jl., vol. 2, no. 10, Oct. 1928, pp. 401–402. It is shown that with four-high mills, operating economy is to some extent dissipated by elastic compression of working and supporting mills; actual saving effected is explained as due to fact that drawing process takes place on portion of mill train under very favorable conditions. Abstract translated from Zeit. fuer Metallkunde, Aug. 1928.

Metal Flow in Rolling. Experimental Investigations on Metal Flow in Rolling, N. Metz. Rolling Mill Jl., vol. 2, no. 10, Oct. 1928, pp. 419–422, 11 figs. Article is based on information obtained by experiments at German Iron and Steel Institute on flow of metal in various shapes of passes; material flow in square pass formed from oval, in round produced from oval, in rail upsetting passes.

Roll-Pass Design. Roll Pass Design, W. Trinks. Rolling Mill Jl., vol. 3, no. 1, Jan. 1929, pp. 13–18, 5 figs. General introduction to roll-pass design; definition of terms, description of various types of rolling mills, passes, rolls; problems of design.

Roller Bearings for. Development and Application of Timken Tapered Roller-Bearings for Steel Mill Equipment, F. Waldorf. Eng. Soc. West. Pa.—Proc., vol. 44, no. 9, Dec. 1928, pp. 283–297 and (discussion) 298–304, 12 figs. Experiences with roller bearings on various kinds of steel rolling mills; pressures on bearings; list of types of mills using taper roller bearings.

Use of Roller Bearings in Rolling Mills, G. Palungren. Stahl und Eisen (Duesseldorf), vol. 49, no. 4, Jan. 24, 1929, pp. 101–108, 14 figs. Types of roller bearings which have been successfully used in Sweden and which were described by G. Palmgren in Jernkontoret Annalen, vol. 112, 1928, p. 116; S.K.F. two-bearing types for standard hot rolling mills; use of roller bearings in universal plate and cold rolling mills.

Sheet Mills. Sheet Mill Furnace Installation at Youngstown Sheet and Tube Company, F. W. Manker. Fuels and Furnaces, vol. 7, no. 1, Jan. 1929, pp. 109–111, 4 figs. Sheets are annealed in continuous and automatic kiln-type furnaces, pickled and then tinned in 20 automatic tinning machines, each tinning unit consisting of tin pot, tinning machine, and combustion chamber with system by which close control of temperature is obtained.

S

SAND, FOUNDRY

Testing. Investigation Into Molding Sands, H. Nipper and E. Piwowarsky. Foundry Trade Jl., (Lond.), vol. 40, no. 649, Jan. 24, 1929, p. 63, 1 fig. Permeability of molding sands was examined by measuring pressure necessary for driving definite quantity of gas through sand test piece in unit of time; results of experiments are recorded in tables. Abstract translated from Giesserei, Nov. 2, 1928.

SCREW THREADS

Milling. Some Observations on Thread Milling, N. N. Sawin. Am. Mach., vol. 70, no. 2, Jan. 10, 1929, pp. 43–46, 7 figs. Results of experimental data worked out in tabular form showing circumferential speed of cutters and feed of work for different materials; correct operation requires determination of relation of circumferential speed of cutter to that of work and to number of cutter teeth. Author is research engineer, Skoda Works, Pilsen, Czechoslovakia.

SLAG WOOL

Uses and Properties. Use and Properties of Slag Wool (Verwendbarkeit und Eigenschaften von Schlackenwolle), A. Guttmann. Stahl und Eisen (Duesseldorf), vol. 49, no. 4, Jan. 24, 1929, pp. 97–101, 3 figs. Notes on useful possibilities of slag wool, its production and adaptability of different blast-furnace slags; its characteristics, appearance, strength of threads, sintering temperature, with special consideration of heat and sound-insulating properties, such as volumetric gravity and heat conductivity; water absorptivity and corrodibility through slag wool.

SPRINGS

Leaf, Manufacture of. Spring Making Machinery. Locomotive (Lond.), vol. 35, no. 437, Jan. 15, 1929, pp. 19–22, 3 figs. Laminated springs for railway vehicles; various operations which can be performed by a group of machines are briefly described; comments on these operations; brief description of each machine; forging machines, seven-operation, triple-headed, double-headed; eye-rolling machine, single-stroke, and three-operation, taper-rolling machine; spring-plate forming machine.

Monel-Metal. Monel Metal Springs for High Temperatures, G. V. Pickwell. Wire, vol. 4, no. 2, Feb. 1929, pp. 47–48 and 62–63, 3 figs. Effects of heat on performance, hardness, and strength of rustproof and corrosion-resistant springs; article formulates from experimental data guide for use of springs made of monel metal when operating at elevated temperature; answers some questions often asked manufacturer of spings; controlling set; higher resistance alloys. Reprinted from Inco.

STEAM ACCUMULATORS

Ruths. The Ruths Steam-Accumulator Installation at the River Don Steel Works, Sheffield. Engineering (Lond.), vol. 127, no. 3288, Jan. 18, 1929, pp. 73–76, 15 figs. Details of installation recently started up at works of

Vickers-Armstrong at Sheffield; accumulator consists essentially of cylindrical shell, built up of riveted-steel plates, with hemispherical ends; shell is covered with heat-insulating material; most important feature of installation is automatic control valves which regulate charging and discharging of accumulator and maintain constant pressure in steam mains.

STEAM CONDENSERS

Surface. Longitudinal Distribution of Steam Improves Performance of Surface Condensers, P. Bancel. Power, vol. 69, no. 9, Feb. 26, 1929, pp. 350–353, 8 figs. Necessity of longitudinal distribution and advantages of subdivided condenser with air removal for each compartment are set forth; refers to single-pass condenser serving new unit at Hudson Ave. Station, Brooklyn, which is subdivided into compartments by tube-support sheets with independent steam-jet air removal for each compartment; in some cases, air cooler, and devaporizer are placed ahead of each vaccum pump.

STEAM-ELECTRIC POWER PLANTS

England. Extensions of Barton Power Station. Power Engr. (Lond.), vol. 24, no. 274, Jan. 1929, pp. 8–10, 3 figs. Description of additions to central station; three new Babcock boilers, having normal steaming capacity of 130,000 lb. per hr., maximum ratings being 150,000 lb. per hr. for stoker-fired boilers and 170,000 lb. per hr. for unit using pulverized fuel; new generating set is Metropolitan-Vickers machine of 40,000-kw. capacity running at 1500 r.p.m.; main alternator said to be largest so far manufactured in Great Britain is 40,000-kw., 0.8 power factor, 6600-volt unit.

Fuel Economy. Fuel Control in Electric Power Stations, F. Munzinger. World Power (Lond.), vol. 11, no. 61, Jan. 1929, pp. 29–31, 2 figs. Author points out principal means of achieving cheaper electricity; since these aims are partly contradictory he shows how they may be balanced in order to improve overall economy as far as possible; advantages of high boiler pressures and steam temperatures; feedwater reheated by bled steam; reheating improvements to furnaces; effective cooling down of flue gases; preheating of combustion air. Abstract of paper read before Inst. of Fuel.

Lake Pauline, Tex. Six Months From Ground to Current on Switchboard, R. B. Niese, Jr. Power, vol. 69, no. 6, Feb. 5, 1929, pp. 239–240, 1 fig. Record accomplishment in erection of 18,750-kva. steam station at Lake Pauline, Tex.; natural gas burned under boilers is supplied from Panhandle gas fields through 8 in. high-pressure main and is delivered to burners at 18 lb.; three 10,000 sq. ft. Stirling-type boilers are installed, operating at 400 lb. and 250 deg. superheat; duplicate two-stage hot-well pumps are direct-connected to variable-speed motors; electricity is generated at 13,800 volts; mechanical equipment is listed.

STEAM ENGINES

Reciprocating, Heat Transmission in. The Transfer of Heat in Reciprocating Engines, A. Nagel. Engineering (Lond.), vol. 127, no. 3287, Jan. 11, 1929, pp. 59–60, 3 figs. Notes on fundamental experiments and early endeavors to understand heat transfer between working substance, and cylinder walls, in case of steam engine.

STEAM PIPE LINES

Calculation. Chart for Solving Steam and Water Piping Problems, P. M. Gallo. Power, vol. 69, no. 8, Feb. 19, 1929, pp. 315–317, 1 fig. Chart is presented for those who are concerned with determination of proper size of pipe in steam or water installations; based on pounds of steam required per minute and steam pressure, as these are furnished by manufacturers of various units, and are first rational quantities encountered in design of power plant or boiler unit; operation of chart is explained.

STEAM POWER PLANTS

Power and Process. Balancing Heat and Power in Industrial Plants, R. V. Kleinschmidt. Power, vol. 69, no. 6, Feb. 5, 1929, pp. 250–252, 3 figs. Importance of various factors in increasing amounts of by-product power that can be generated in industrial plants using process heat; hot air can be most economically used by returning it to boiler furnace and heating air for process work with exhaust steam; advantages of two-stage water heating as compared with heating by exhaust steam only; best condenser vacuum for initial and final temperatures of water in two-stage process. Abstract of paper read before Am. Soc. Mech. Engrs.

STEAM TABLES

Callendar. Extension of the Callendar Steam Tables, H. L. Callendar. World Power (Lond.), vol. 11, no. 61, Jan. 1929, pp. 11–16, 4 figs. Author endeavors to deal with questions most frequently raised regarding extension of steam tables; adiabatic equation for dry steam; experiments on saturation volumes; total heat of water; specific heat of dry steam; equations by direct experiment to 4000 lb. per sq. in. and 800 deg. fahr. Report from Brit. Elec. and Allied Industries Research Assn.

STEAM TURBINES

Back-Pressure. Efficiency of Modern Back-Pressure Steam Turbines (Die Guetezahl neuzeitlicher Gegendruck-Dampfturbinen), A. Renfordt. Archiv. fuer Waermewirtschaft (Berlin), vol. 10, no. 1, Jan. 1929, pp. 22–24, 4 figs. Fundamentals for appraisal of back-pressure turbines from analysis of losses; influence of wheel diameter; most economical wheel diameter is determined.

Blades. Increasing the Life of Steam Turbine Blades, B. Anoschenko. Elec. Jl., vol. 26, no. 2, Feb. 1929, pp. 86–87, 3 figs. Description of machine for determining performance of turbine blades under vibration and comparison of effect of three different methods of lashing on blade life.

Condensation. Undercooling of Condensed Water in Steam Turbine Plants (Die Unterkeuhlung des Kondensates in Dampfturbinenanlagen), Schlicke. Elektrotechnische Zeit. (Berlin), vol. 49, no. 52, Dec. 27, 1928, p. 1882. Author advises determination of average annual temperature of circulating water prior to design of condensing plant, since too much and too cold circulating water undercools condensed water and increases steam volume.

Lubrication. Lubrication of the Steam Turbine, A. F. Brewer. South. Power Jl., vol. 47, no. 2, Feb. 1929, pp. 74–81, 12 figs. Impairment or cessation of lubrication may occur wherever oil grooves in bearings, or oil piping becomes clogged or obstructed by sludge; these may be developed through use of contaminated lubricants or oils which have not been properly refined; factors to be considered in connection with initial selection and subsequent reconditioning of oil; oil must be kept cool; where oxidation may occur.

STEEL

Quenching. The Quenching of Steel, P. J. Haler. Engineering (Lond.), vol. 127, no. 3286, Jan. 4, 1929, pp. 25–26, 8 figs. View is advanced that warping is largely due to action of quenching fluid, which produces differential cooling on various faces; it has been shown that, in severe quenching, periphery of cube is always softer than central portions, this anomalous phenomenon being explained by presence of arrested austenite in martensite; it is suggested that uneven cooling, as explained in this paper, causes this phenomenon.

Temperature Effect. Strength of Low Carbon Steels at High Temperatures, R. G. Batson. Engineer (Lond.), vol. 146, no. 3807, Dec. 28, 1928, pp. 707–709, 8 figs. Work described was carried out at Engineering Department of National Physical Laboratory, undertaken at request of Engineer Surveyor-in-Chief to Board of Trade; results of tests on steel up to approximately 650 deg. cent.; results of tests on 0.10 per cent carbon steel between 500 and 650 deg. cent. are also given; general discussion of "creep" results.

Yield Point. The Physical Significance of the Yield Point. Metallurgist (Supp. to Engineer, Lond.), Dec. 28, 1928, pp. 186–187. Review of two articles recently published in German technical press; first by W. Kuntze and G. Sachs in V.D.I. Zeit., July 21, 1928, describes experiments carried out with new silicon steel, which has well-defined yield point; authors interpret their results as affording strong indications of presence of brittleness; second paper, by Kuehnel, V.D.I. Zeit., Sept. 1, 1928, deals with importance of yield point to designer.

STEEL CASTINGS

Heat Treatment. Heat Treatment of Carbon and Alloy Steel Castings, J. E. Donnellan. Iron Age, vol. 123, no. 5, Jan. 31, 1929, pp. 342 and 344. Problems in quenching alloy steel castings; double normalizing treatment of carbon steel castings; alloy castings should, in most cases, be tempered after normalizing, to relieve brittleness and strain caused from air quench and also to increase ductility and impact values; avoiding warping and straightening; metallography of two steels. Abstract of paper presented before Western Metal Congress.

STRUCTURAL STEEL

Welding. Progress in Welding of Buildings and Bridges, F. P. McKibben. Can. Machy. (Toronto), vol. 39, no. 26, Dec. 27, 1928, pp. 246–248, 3 figs. Possibilities welding offers in eliminating noise and reducing costs in construction of steel building frames; shops can install at very little expense sufficient welding equipment to shop-weld steel for ordinary building; trusses in General Electric Co.'s Bridgeport plant; beam and column building of General Electric Co. at Pittsfield, Mass.; use of erection bolts; advantages of welding; current welded construction; strengthening steel structures. Abstract of address presented before Electrical Club, Toronto.

T

TEXTILE MILLS

Air Conditioning. Humidity a Greater Factor Than Ever in Textile Manufacturing, R. H. Brown. Textile World, vol. 75, no. 5, Feb. 2, 1929, pp. 185–186, 2 figs. Solution to difficulties greatly increased humidifying capacity, sufficient actually to produce desired relative humidities at all times; table lists evaporative capacities considered good cotton-mill practice at various times in past and today; cooling mill rooms; humidity for rayon.

Conveyors. Adaptability of Mechanical Conveyors to Textile Plant Conditions, C. M. Mumford. Textile World, vol. 75, no. 5, Feb. 2, 1929, pp. 191–192, 387, 389, 6 figs. Special conditions in mills; automatic features essential; problems of original installation; handling bobbins and spools; change in doffing boxes; operation of automatics; type of container; in moving stock horizontally and vertically traveling belt gives best satisfaction; advantages of conveyors.

Power Equipment. Many Developments in Power, Maintenance and Repair Service. Textile World, vol. 75, no. 5, Feb. 2, 1929, pp. 375–376 and 468, 4 figs. Important new development in power-plant equipment is application of steam-turbine drive to underfeed gravity inclined type of stoker; power for night work; Diesel engine; variable-speed motor; varying yarn tension; frame speeds; reduction of wastes; airplane propeller fan; automatic temperature control; mechanical department.

TURBO GENERATORS

Hell Gate Station. 160,000-KW. Steam Turbo-Generator for the Hell Gate Power Station, New York. Engineering (Lond.), vol. 127, nos. 3286 and 3288, Jan. 4 and 18, 1929, pp. 1–8 and 65–69, 95 figs. partly on p. 16 and supp. plates. Jan. 4: Particulars of installation, supplied by Brown, Boveri & Co., which consists of two-shaft cross-compound set, developing 160,000 kw. in continuous running; main problem to be solved was to provide full-load capacity, combined with good and uniform efficiency at partial load; general layout of plant. Jan. 18: Steam-controlling gear; governors and governor valves; high-pressure coupling, etc.

V

VULCANIZED FIBER

Machining. The Machining of Vulcanized Fiber, N. S. Baer. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 451–452, 1 fig. Machining of fiber presents many difficulties unless certain easily followed directions are observed; many shapes and sizes in which fiber is available; approved methods of machining; cutting speeds for sawing; punching, shaving, turning, boring, drilling, tapping, threading, milling, planing, bending, and forming fiber; use of automatic machines in cutting; coefficient of friction of fiber and other material; physical properties.

W

WAGES

Tool-Room Bonus System. Bonus System Increases Toolroom Output Forty Per Cent. E. Gibian. Machy. (N. Y.), vol. 35, no. 6, Feb. 1929, pp. 401–405, 8 figs. Description of incentive payment plan employed in toolroom of Vlchek Tool Co., Cleveland, Ohio, that has increased income of toolmakers and reduced costs of company; preparations made for installing bonus system; controlling payment of bonuses; toolmakers punch clock in starting and stopping each operation; daily report of tool-room performance; charts keep management apprised of tool-room conditions.

In Two Sections—Section Two

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 51 April, 1929, Section Two Number 4

What It's All About

THE pages of MECHANICAL ENGINEERING constitute a forum in which are discussed the timely problems of professional interest which keep engineers in step with progress. Although the treatment is necessarily technical, the subject-matter is none the less of practical value to laymen, because the structures of modern civilization rest upon the foundations which science and engineering prepare. Mechanical engineering is essentially concerned with the technical aspects of industrial life, the generation of power and its economical utilization, the selection and use of materials for specific purposes, and the production of whatever men and machines prepare for the markets of the world. As an aid to science, engineering transmutes theory and research into practical instruments for the benefit of mankind.

This present supplement to MECHANICAL ENGINEERING for April comments in non-technical language on the contents of its pages. Read it, and pass it on. Engineers have only themselves to blame if those outside of the profession show little interest in features of modern life which affect the industrial era in which they live.

High-Pressure Steam

IN A PAPER before the A.S.M.E. on " 'Promise and Potency' of High-Pressure Steam" presented at the Annual Meeting of the Society in December, 1896, Dr. R. H. Thurston submitted a curve showing the increase in steam pressure in power-plant practice from 1800 to the date of his paper. Starting in 1800 at 20 lb. absolute pressure, or only five pounds above the atmospheric, the curve shows a gradual rise of only 10 lb. in the first fifty years, and from then on a steeper ascent to 250 lb. in 1896. A projection to 300 lb. at the end of the century was hazarded by Dr. Thurston, with a further prediction that 500 lb. would probably be reached in 1910 or 1920.

At the present time there are in operation in this country boiler plants generating steam at 1200 and 1400 lb., and in Europe even higher pressures are used. The number of these plants is comparatively small, and the developments which are being carried out in them are of a pioneering nature. The evidence seems to be, however, that plants operating at these high pressures can be justified on thermodynamic and economic grounds, not only for central stations but also for industrial power stations.

Considerable space is devoted in this month's MECHANICAL ENGINEERING to high-pressure steam plants. The operating experiences at the Edgar Station of the Edison Electric Illuminating Company of Boston are described by I. E. Moultrop. This station is perhaps typical of practice in this country, which has attempted to adapt existing types of steam-generating equipment to the more severe service of much higher pressure. There is also a paper by Jaroslav Havlicek describing a European plant which generates steam at 1700 lb. pressure and which is typical of a European approach to the problem. In the Löffler boiler which is used in the plant described by Havlicek, the designer has cut loose from conventional types of boilers and, having in mind the special problems which are the concomitants of high pressure, has developed a steam generator of marked originality.

Those who have followed the development of high-pressure boilers will be particularly pleased with the frank treatment of operating experiences which Mr. Moultrop presents, and by the interesting details of the European plant and its operation.

As further contributions to the subject of high-pressure steam plants, comments on the American and European points of view by A. R. Smith, of the General Electric Company, and Professor S. Löffler, designer of the Löffler boiler, are included. The fortunate coincidence of the receipt of Dr. Havlicek's manuscript and the presentation of Mr. Moultrop's paper before the Metropolitan Section of the A.S.M.E., together with the willingness of Mr. Smith and Professor Löffler to offer discussion, have made it possible for MECHANICAL ENGINEERING to present this valuable contribution to the literature of high-pressure steam practice in its April issue.

Industrial Research

BEFORE the War, graduates of universities in this country flocked to Europe, and quite generally to Germany, for further training in their specialties. Here they learned by painstaking research how to advance knowledge. When they returned to this country, the spirit of research animated their scholastic activities, and they built up research organizations of their own.

From the classics and the pure sciences, the spirit of research has spread to industry where emphasis has been laid on practical problems needing immediate solution. As an industrial nation, Germany has developed her research activities to include the problems of industry. During a recent trip abroad, J. M. Spitzglass, as secretary of the A.S.M.E. special research committee on fluid meters and working for international cooperation in this branch of research, was able to study at first hand the situation in Germany. In the April issue of MECHANICAL ENGINEERING appears his report to the main research committee of the A.S.M.E. Of special interest to those engaged in industrial research in this country will be the list of research committees and projects of the V.D.I.

Science and Engineering

SCIENCE enables engineers to understand more clearly the problems which face them in the utilization of the forces and materials of nature. Science is continually opening up new fields for the talents of the engineer to cultivate. The engineer must keep abreast of science, as a